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ABSTRACT

This document contains the full and short papers on multimedia and hypermedia in education from ICCE/ICCAI 2000 (International Conference on Computers in Education/International Conference on Computer-Assisted Instruction) covering the following topics: learner-centered navigation path planning in world Wide Web-based learning; the relation between touch-typing skill and thinking-typing; a virtual classroom for algorithms with algorithmic support; an adaptive navigation support with reorganized learning resources for Web-based learning; design and use of a multimedia composition-making system for children; an automated quantitative extraction method of aesthetic impression from color images; building the multi-tier architecture of component-oriented multimedia CAI (Computer-Assisted Instruction) systems on the Internet; CAI system generator on the Web using automatic trace recording; CoCoAJ (Communicative Collection Assisting System for Java)--supporting online correction of hypermedia documents for CALL (Computer-Assisted Language Learning); designing and implementing CAI programs for adult literacy learners; design for interactivity; design of multiple metaphors in user-interface; development of 3D simulation programs for classical mechanics; evaluating educational multimedia; learner control in technology-mediated learning within a constructivist model; learners' structural knowledge and perceived disorientation in a hypermedia environment--the effects of information conveying approaches and cognitive styles; learning algorithm design through interactive simulation; making exploration history interactive for Web-based learning; models and strategies for promotion of distance learning in primary schools and high schools; multimedia design for chemical visualization; multimedia intelligent tutoring system for context-free grammar; multimedia whiteboard design in Web-based remote cooperative education system; multimedia-based teaching material for learning digital signal processing; MyEnglishTeahcer--a Web system for academic English teaching; natural language-like knowledge representation for multimedia educational systems; supporting semantic indexing in a mediabase system that facilitates collaborative learning; SimPCS: a Web-based PCS (Personal Communication System) learning tool; students' thinking processes when learning with

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computer -assisted mass lectures; system development for learning through the Internet, providing function to make Chinese characters readable for students; the automated teaching assistant--automatic contraction of teaching materials from course outlines; the criteria and evaluation of metadata/keywords in image retrieval; the development and evaluation of a learning support system for converting Web pages; the estimation of music genres using neural network and its educational use; the rhetoric of the Web--a semiotic approach to the design and analysis of Web-documents; visual presentation format and knowledge discrepancy in scientific learning; and Xtrain--a graphical user interface-based tool for multimedia presentations, instruction, and research. (MES)

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The Estimation of Music Genres Using Neural Network and its Educational Use

The Rhetoric of the Web. A semiotic approach to the design and analysis of Web-documents

Visual Presentation Format and Knowledge Discrepancy in Scientific Learning

Xtrain: A GUI based tool for Multimedia Presentations, Instruction, and Research

▲ HOME

A Learner-Centered Navigation Path Planning in Web-based Learning

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The main issue addressed in this paper is how to help learners navigate in existing web-based learning resources. Towards this issue, we introduce a learner-centered navigation path planning. The key idea is to provide learners with a space, in which they can see through WWW pages to plan a navigation path. In this paper, we also demonstrate an assistant system, which is composed of hyperspace map, page previewer, and path previewer. The page previewer generates an overview of each WWW page in the map by extracting representative information from the HTML file. The path previewer helps learners make a sequence of the pages previewed as navigation path plan. These facilities help learners decide which page to visit and plan a navigation path without visiting hyperspace. This paper also describes a preliminary evaluation with the assistant system. The results indicate that the system facilitates learning and navigation in a more complicated hyperspace.

Keywords: Navigation Path Planning, Learner-Centered, Page Previewer, Path Previewer

1 Introduction

An increasing number of hypermedia/hypertext based resources on the Web has been available, which are designed from an educational point of view, or which are worth learning. Learning with such existing web-based learning resources has accordingly become important, particularly as the realization of lifelong and distance learning.

Web-based learning resources provide learners with hyperspace where they can explore domain concepts/knowledge in a self-directed way from a WWW page to others by following the links among pages to achieve a learning purpose. However, learners often fail in making the navigation path since they do not know which link to follow for achieving their learning purpose due to the complexity of hyperspace [3], [9]. They may alternatively reach an impasse due to a cognitive overload, which is caused by diverse cognitive efforts at setting up local learning purposes, comprehending the contents included in nodes, etc., in the exploratory learning [6], [11]. How to facilitate learners' navigation and learning is consequently a major issue in educational hypermedia/hypertext systems [1], [11].

The main topic addressed in this paper is how to help learners navigate in existing web-based learning resources. Current work on educational hypermedia/hypertext systems has provided a number of navigational aids such as spatial/concept maps and adaptive navigation [1], [4], [5]. However, these aids can not be always available to existing web-based learning resources since it is hard to grasp semantic relationships among the WWW pages, on which the navigational aids are founded, without analyzing the contents of the learning resources.

In this paper, we discuss a learner-centered navigation path planning. The key point of this idea is to provide learners with a space, in which they can see through web-based learning resources to make a navigation path plan, apart from hyperspace. Such planning space is also expected to facilitate their learning since they can focus mainly on comprehending the contents of the learning resources in hyperspace. We have accordingly developed an assistant system for the navigation path planning. This system provides learners not only with hyperspace map but also with page previewer and path previewer. The page previewer extracts information attached to some HTML tags in a WWW page, which can be considered representative of the page, from the HTML file, and displays it as an overview of the page. The path previewer also makes a sequence of the pages previewed, and displays it as navigation path plan. These facilities help learners decide which page to visit and make a navigation path plan without visiting hyperspace.

This paper also describes a preliminary evaluation of learner-centered navigation path planning with the assistant system. The results indicate that the system facilitates learners' navigation and learning in hyperspace, particularly in more complicated hyperspace.

Before discussing the learner-centered navigation path planning, let us first consider navigation in hyperspace.

2 Navigation in Hyperspace

2.1 Problems

In hyperspace, learners can explore nodes in a self-directed way by following links among the nodes to learn domain concepts/knowledge embedded in the explored nodes. The exploration involves making a path called navigation path [9]. However, learners can not foresee what they can explore next from the current node and can not decide which link to follow for achieving their learning purpose, often failing to make their navigation path [11]. This is mostly caused by the complexity of hyperspace. The learners may alternatively reach an impasse since they need to concurrently make diverse cognitive efforts at setting up local learning purposes, comprehending the contents explored, etc., in exploratory learning [6], [7], [11].

2.2 Navigation Aids

The important points towards the navigation problem are how to give learners an unobstructed view of hyperspace and how to call their attention to making a navigation path.

As current representative navigational aids, there are spatial maps and concept maps. Spatial maps represent nodes and links that compose the structure of hyperspace [4], [8]. Concept maps consists of nodes and links representing the structure of domain concepts to be learned, which nodes are mapped on the corresponding nodes in hyperspace [5]. In both of spatial and concept maps, nodes are tagged with their titles, which are intended to represent the contents of the nodes. In concept maps, links are also tagged with descriptions representing the semantic relationships between the nodes. Although such tag information may be insufficient for learners to make a navigation path plan, the spatial and concept maps provide learners with a space, apart from hyperspace, for considering navigation paths.

Another solution to the navigation problem is adaptive hypermedia, which supports navigation in hyperspace by annotating nodes and links to be visited, hiding nodes and links not to be visited, etc [1]. Such adaptive navigational aids are founded on semantic relationships among domain concepts/knowledge and learners' exploration status.

These above representative navigational aids would generally work well in educational hypermedia/hypertext whose semantic structure has been given or analyzed [2]. However, it is doubtful whether they apply to web-based learning resources [12]. Existing web-based learning resources mostly have no concept maps. It is also hard to identify semantic structure of domain concepts/knowledge embedded in the learning resources. Although there are web-based learning resources with site maps, the anchors included in the maps do not always allow learners to foresee the contents of the WWW pages. In addition, adaptive navigational aids are not always applicable since existing web-based learning resources generally have no clear description of semantic relationships among WWW pages, which is indispensable for executing the adaptation. In order to apply these navigational aids to existing web-based learning resources, it is necessary to analyze semantic structure of the domain concepts/knowledge beforehand. In this paper, however, we address the issue of how to support learners' navigation without the analysis.

2.3 Navigation Path Planning and Execution

Let us now introduce a learner-centered navigation path planning. The key idea is to provide learners with a space where they can plan a navigation path with an overview of each WWW page. In other words, learners have two spaces, which are space for navigation path planning and hyperspace for executing the plan. In the planning space, learners decide which page to visit and the sequence of pages visited. In the hyperspace, they are expected to explore hyperspace as planned. The navigation path planning and plan execution are repeated during learning in hyperspace.

The distinction between navigation path planning and plan execution allows learners to focus mainly on comprehending the contents of learning resources in hyperspace. Since the navigation path plan also gives learners an overview of the contents to be learned before exploring hyperspace, their learning can be improved.

3 Learner-Centered Navigation Path Planning

We next discuss how to support learner-centered navigation path planning and demonstrate an assistant system that has been already implemented.

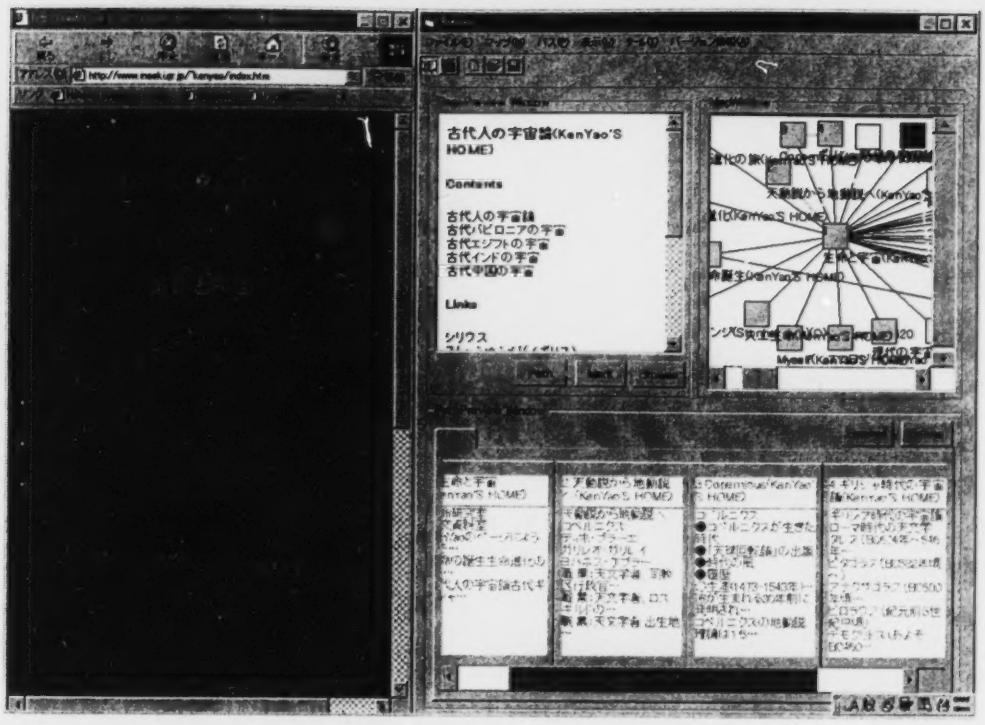

Figure 1. User Interface.

3.1 Framework

Let us first consider what kind of information should be presented for supporting navigation path planning. Although spatial maps of web-based learning resources are necessary for considering navigation paths, the maps alone may be insufficient for learners as mentioned above. It is indispensable to provide them with some additional information. However, planning with the full contents of the WWW pages causes the same navigation problem as hyperspace usually produces. This suggests the necessity to give learners an informative overview of the contents. In this paper, we introduce a page previewer that tries to extract keywords, sentences, or images to be considered representative from a WWW page to display them as the preview of the page.

In addition, the navigation path planning involves considering the relationships between WWW pages explored, changing the plan, and replanning over again. We accordingly introduce a path previewer that makes a sequence of the previewed pages the learners want to visit. The path previewer helps the learners plan, change, and remake navigation path with the sequence of the previewed WWW pages.

Figure 1 shows a user interface of the assistant system for learner-centered navigation path planning. The system is composed of spatial map, page previewer, and path previewer. The spatial map represents hyperspace of a web-based learning resource selected by learners as network of nodes corresponding to the WWW pages. It is automatically generated and displayed in the map window when they select the learning resource. The spatial map represents the WWW pages only within the same WWW site where the homepage selected by the learners is located. The links from the site to others are omitted. Nodes in the spatial map are tagged with page titles indicated by title tags in the HTML files.

In the spatial map, the node corresponding to the WWW page learners currently visit with browser is colored with red. The learners can start planning a navigation path from the current node by following the links. The path planned is restricted by the structure of the spatial map. In left mouse-clicking a node, they can have an overview of the WWW page corresponding to the clicked node in the page preview window. The color of the node previewed is also changed into red. Nodes next to the red node are also colored as yellow. If it is hard to see connections between the red node and the next nodes, a pop-up menu including the titles of the next nodes appears by means of right mouse-clicking the red node. Selecting one title from the menu, learners can see an overview of the corresponding node in the page preview window.

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Table 1. HTML Tags Searched.

HTML Tags	Meanings
- About contents	
1.Title	Title of page
2.H1 to H3	Headings of page
3.Font Size/Color/Face	Font size, color, and figure
- About links	
A href	Link to another page
- About images	
Img	Image file

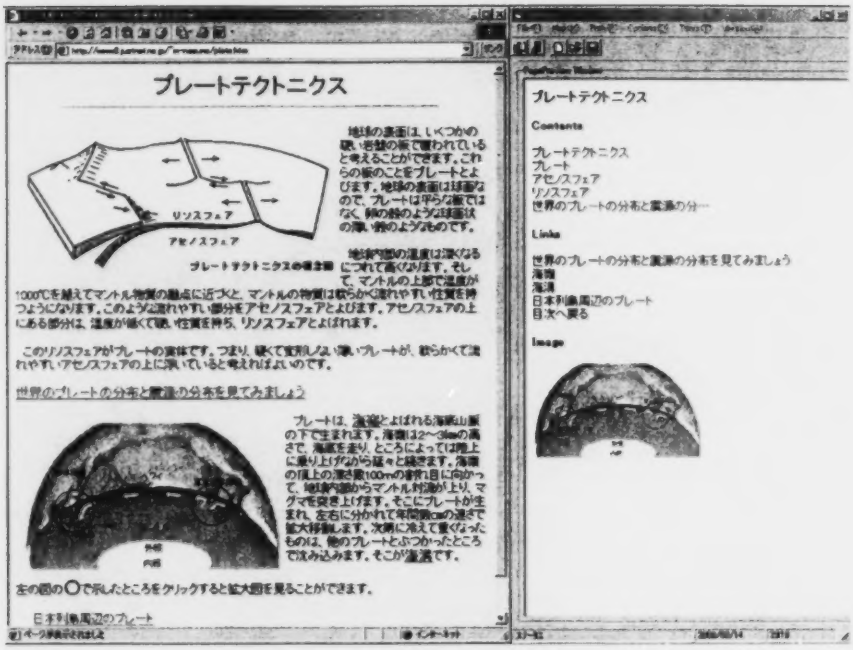

Figure 2. An Example of Page Preview.

The learners can also put the previewed node in the path preview window, making a navigation path plan. The learners are expected to explore hyperspace as planned with browser. When they want to change or cancel the navigation plan during the exploration, they can return to the navigation path planning windows and remake a new path.

In the following, let us explain the page previewer and path previewer in more detail.

3.2 Page Previewer

The important point to generating an overview of a WWW page is how to extract information representing the contents of the page. Assuming that such information is located with the HTML tags shown in Table 1, the page previewer extracts words, sentences, or images indicated by these tags to display them as page preview. We heuristically consider such assumption valid. Figure 2 shows an example of the page preview. The right window shows the preview of a WWW page shown in the left window.

The information extracted from a WWW page is classified into the contents, the links out of it, and images included. As for the contents, the page previewer searches for the HTML tags in order from top to bottom in Table 1, and extracts words or sentences attached to the tags. When extracting a sentence, it displays not all words but

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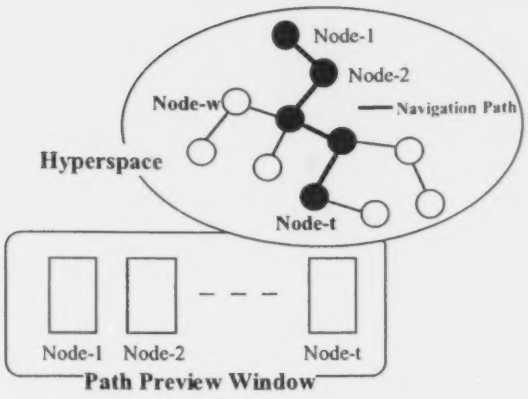


Figure 3. Restriction on Navigation Path Planning.

fifteen words from the head of the sentence. If the number of HTML tags included in the HTML file is large, the page previewer deals with ten HTML tags that are searched from the top in Table 1. For example, let us consider a WWW page including a large number of HTML tags such as one title tag, six *H1* tags, seven *H2* tags, nine *H3* tags, etc. In this case, the page previewer focuses on ten tags, which are the title, six *H1* and three *H2* tags, and displays the information attached to these tags.

As for the links out of the page, the page previewer searches for *A href* tags in the HTML file to display the descriptions of the links. If the descriptions indicate the URL, they are not displayed. If the number of *A href* tags is large, the page previewer displays only five link descriptions to be found from the head of the HTML file. As for the images included in the page, the page previewer searches for *Img* tags in the HTML file, and displays one image whose file size is the largest.

Learners can see the preview of a WWW page by mouse-clicking the corresponding node in the spatial map. Since the node previewed is colored with red, they know where they are previewing in the spatial map. If they can not foresee the contents of the page, they can push the *Browse* button under the page preview window or double-click the node to look at the full contents in browser. However, these operations are not recommended in planning. In making a navigation path plan, the learners can include the node previewed in their navigation path by pushing the *Path* button. Mouse-clicking the *Mark* button, in addition, they can mark the node previewed, which they do not want to immediately put in the path preview but to memorize.

3.3 Path Previewer

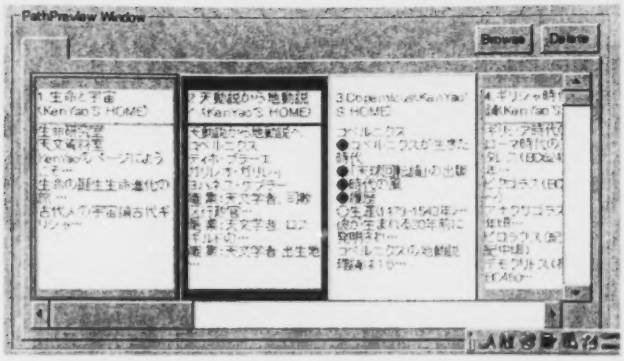
In the path preview window, the path previewer sequences the nodes previewed, which nodes are put in order by learners. The order of the previewed nodes represents a navigation path plan. The adjacent nodes are also adjacent each other in hyperspace. If the learners attempt to put a node in the sequence, which is not directly linked to the tail node of the sequence in hyperspace, the path previewer disables the *Path* button. For example, let us consider a learner who works out a navigation path plan as shown in Figure 3. If he/she tries to put *Node-w* in the plan, he/she is provided with a warning from the path previewer since the *Node-w* is not linked to the tail node (*Node-t*) of the sequence in hyperspace. In this way, the navigation path planned has to follow the link structure of hyperspace.

The learners can also delete any node in the navigation path plan by mouse-clicking it and selecting *Delete* button in the upper right corner of the path preview window. In order to help learners select one of some branches from a node, the page previewer additionally displays these branches with some path preview windows concurrently.

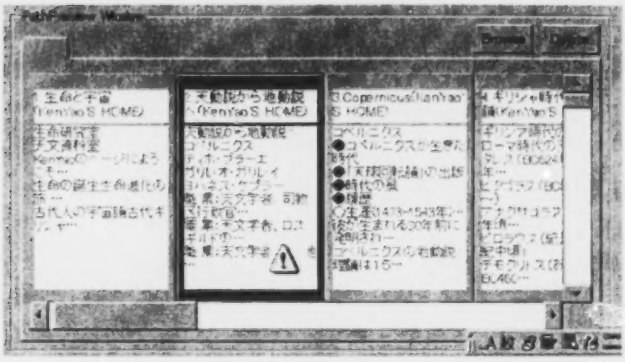
3.4 Plan Execution and Replanning

Using the page preview and path preview windows, learners are expected to decide a navigation path and then to start exploration in hyperspace. They are also expected to follow the navigation path plan during the exploration. The node in the plan corresponding to the WWW page, which the learners currently browse, is framed with blue. This allows them to know which node they are browsing. When they put the mouse-cursor on a link in the WWW page, which link indicates the node next to the framed node, the node is also framed with yellow such as Figure 4(a). This also allows them to know which link to follow in the WWW page.

The learners do not always need to follow the plan. They can explore nodes with browser, which are not included



(a) Attention to Next Page.



(b) Warning.

Figure 4. Attention and Warning in Path Preview Window.

in the plan. As shown in Figure 4(b), however, the path previewer put a warning icon on the node at which the learners run off in the plan. When they also want to change or cancel the navigation plan during the exploration, they can return to the navigation path planning windows and remake a navigation path plan from the node corresponding to the current page on browser.

In this way, learners are expected to repeat the navigation path planning and plan execution to accomplish the exploratory learning in hyperspace.

4 Preliminary Evaluation

4.1 Experiment

In order to evaluate the effectiveness of learner-centered navigation path planning with the assistant system, we have had a preliminary experiment. The main purpose of this experiment was to ascertain if navigation path planning with the system facilitates navigation and learning in hyperspace compared to navigation and learning without the system. We also prepared two learning resources, which had comparatively simple and complicated hyperspace, and ascertained for which resource the system can assist in navigation and learning more effectively.

Table 2 shows the two learning resources, which describes the number of pages, the number of links per page, which was calculated except for navigation links such as *Next*, *Back*, and *Top*, and the longest distance from the homepage to terminal page that has no link. These can be viewed as the indicators of the complexity of hyperspace each learning resource provides. The learning resource 2 accordingly had a more complicated hyperspace. Subjects were 7 graduate and undergraduate students in science and technology.

We set four conditions, which were (1) planning and execution with the system in the learning resource 1 (*Simple-With*), (2) exploration in the learning resource 1 without the system (*Simple-Without*), (3) planning and execution with the system in the learning resource 2 (*Complicated-With*), and (4) exploration in the learning resource 2

Table 2. Learning Resources.

	Learning Resource 1	Learning Resource 2
Number of Pages	32	161
Number of Links per Page	1.2	2.2
The Longest Distance from Homepage to Terminal Page	3	7

Domain of learning resource 1: Life and space.
Domain of learning resource 2: Life in sea.

Table 3. Average Scores of Problem-Solving.

Condition	Total	Single Problems	Compound Problems
Simple-With	75%	100%	60%
Simple-Without	71%	78%	67%
Complicated-With	79%	83%	75%
Complicated-Without	62%	78%	50%

Table 4. Average Scores of Revisit per Page.

	Revisit		Revisit
Simple-With	1.58	Complicated-With	1.83
Simple-Without	1.56	Complicated-Without	4.04

without the system (*Complicated-Without*). Subjects were provided with Microsoft Internet Explorer as WWW browser under each condition. In this experiment, each subject learned one learning resource without the system and learned the other with the system. In other words, he/she was assigned two conditions, which were *Simple-With* and *Complicated-Without* (or *Simple-Without* and *Complicated-With*).

Before learning, subjects were given several problems as learning purposes for each learning resource. The problems were classified into (1) single problems whose answers could be found within one WWW page, and (2) compound problems whose answers could be found in the relationships among two or three pages. In this experiment, the effects on learning were measured by the scores on both problems. The effects on navigation in hyperspace were measured by the number of revisiting pages in hyperspace [10]. The time of learning in each condition was limited to thirty minutes.

The procedure of the experiment with each subject was as follows:

(1)The subject was given the explanation about how to use the assistant system before learning and then single and compound problems for the learning resource 1 or for learning resource 2.

(2)He/she was required to explore answers to the problems. In *Simple-With* or *Complicated-With*, he/she was next required to use the assistant system for making a navigation plan and to use the WWW browser for exploring hyperspace. In *Simple-Without* or *Complicated-Without*, he/she was next required to use only the WWW browser to explore hyperspace. In each condition, he/she was provided with a space where he/she can copy and paste the contents of the WWW page considered as the answers.

(3)When he/she finished finding out the answers or thirty minutes passed, the contents copied and pasted by him/her was checked and the scores was calculated as the percent of corrected answers. The number of revisit per explored page was also checked.

Comparing the scores and the numbers of revisit per page explored under *Simple-With* and *Simple-Without* or under *Complicated-With* and *Complicated-Without*, we evaluated the effectiveness of the assistant system.

4.2 Results and Discussion

Table 3 shows the average score on each condition. The average score (75 %) on *Simple-With* was slightly higher than the average score (71 %) on *Simple-Without*. On the other hand, the average score (79%) on *Complicated-With* was considerably higher than the average score (62 %) on *Complicated-Without*. The difference between the average scores in the compound problems on *Complicated-With* and *Complicated-Without* was particularly large.

Table 4 shows the average number of revisit per page explored on each condition. Although the difference between the average numbers of revisit on *Simple-With* and *Simple-Without* was very small, there was a great difference between the average numbers of revisit on *Complicated-With* and *Complicated-Without*.

The above results indicate that the assistant system produced good effects on learning such as integrating the contents of some pages in a more complicated hyperspace. As for effects on navigation, the system facilitated navigation in a more complicated hyperspace. In a simpler hyperspace, on the other hand, the assistant system could not be so fruitful since it was able to easily see through the learning resource even without the system. Although we need a detailed experiment with more subjects, the assistant system can effectively help learners navigate and learn in a complicated hyperspace.

5 Conclusion

This paper has proposed a learner-centered navigation path planning for learning with existing web-based resources. The important point is to provide learners with a space where they can see through WWW pages to make a navigation path plan. As the advantages, learning in hyperspace can be improved since the distinction between navigation path planning and plan execution allows learners to focus mainly on comprehending the contents of the learning resources in hyperspace. The navigation path plan can also give learners an overview of the contents to be learned before exploring hyperspace.

This paper has also demonstrated an assitant system including page previewer and path previewer. These previewers allow learners to decide which page to visit and make a navigation path plan without visiting hyperspace. In addition, this paper has described a preliminary evaluation of the learner-centered path planning with the system. The results indicate that the system produces good effects on learning and navigation in a complicated hyperspace.

In the future, we need a more detailed evaluation of the learner-centered navigation path planning. We would also like to provide more adaptive aids in the page and path previews.

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A Study on the Relation between Touch-typing Skill and Thinking-typing

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Word processor is more and more widely used as a tool of externalization and reflection of thinking in recent years in Japan. In that case, it will be necessary to type smoothly words or sentences appearing in the head (hereinafter referred to as "thinking-typing"). The experiments were made to study the relation between touch-typing skill and thinking-typing. The examinees were 46 non-computer majors of the university. The students were asked to type words or sentences appearing in their heads on 3 subjects. The touch-typing skill of the students was measured by touch-typing exercise software. The results suggested that a touch-typing speed of 2 strokes/second is necessary, at least, to type smoothly words or sentences appearing in the head. What's more, the results of the experiments suggested that learning of touch-typing skill is very effective on the increase of thinking-typing speed of the subject that is easy to be thought out.

Key words **Thinking-typing, Touch-typing, Externalization, Self-evaluation, Analysis of variance**

1 Introduction

The methods for human beings to externalize their thinking are language expression, diagram expression, letter expression and so on [1]. Among these expressions, letters are widely expressed by word processors in recent years in Japan. The method of word processor's usage has been changed by the popularization of them. In other words, the method that uses a word processor to transcribe a manuscript written by handwriting, has been changed to the method that uses a word processor in the process of externalization and reflection of thinking. With the latter method, it is necessary to type smoothly words or sentences appearing in the head (hereinafter referred to as "thinking-typing"). Thinking-typing needs a certain level of typing skill. Although a number of studies have been made on typing [2][3], there are few studies on thinking-typing.

In the lesson of computer exercise at the university, the first author is raising the level of students' typing skill through touch-typing education and, at the same time, is raising the ability of the students' utilizing a word processor as a tool of externalization and reflection of thinking [4]. In the lesson, the experiments of thinking-typing by touch-typing were made to study the relation between touch-typing skill and thinking-typing. Touch-typing speed and self-evaluation of thinking-typing were adopted as the scale of thinking-typing level. The first experiment (Experiment 1) was made in July, 1999, and the second experiment (Experiment 2) was made in February, 2000. In this paper, results regarding Experiment 2, and comparison between Experiment 1 and Experiment 2 are reported, because results regarding Experiment 1 had been reported already [5][6].

2 Method

The experiments of thinking-typing by touch-typing were made in the lesson of the computer exercise for the first-year students at the university. In this study, the data of 46 students, whose data of Experiment 1 and Experiment 2 were complete, were analyzed. In the experiments, the students typed the following subjects by touch-typing.

【Subjects of Experiment 1】

Subject 1 Type words that you think with *shiritori* (a Japanese word chain game). Type them by *hiragana* (Japanese alphabet). The time limit is 3 minutes.

Subject 2 Type words that you image with "university". Type them by *hiragana-kanji* (Japanese alphabet – Chinese characters) translation. The time limit is 5 minutes.

Subject 3 Type sentences of your self-introduction. Type them by *hiragana-kanji* translation. The time limit is 10 minutes.

【Subjects of Experiment 2】

Subject 1 Same as Subject 1 of Experiment 1.

Subject 2 Type words that you image with "student life". Type them by *hiragana-kanji* translation. The time limit is 5 minutes.

Subject 3 Type sentences of your impression about the lesson of the computer exercise. Type them by *hiragana-kanji* translation. The time limit is 10 minutes.

After the experiment, the students evaluated themselves on the 3 subjects. In Experiment 2, the students evaluated themselves on whether they could think out words and sentences or not (thinking evaluation), whether they could type words and sentences by touch-typing or not (typing evaluation). The evaluation standard was divided into 6 levels "very good", "good", "a little good", "a little bad", "bad" and "very bad".

The touch-typing skill of the students was measured in the lessons before and after the lesson of the experiments. The measurement content is testing typing time of entering Japanese sentences of *hiragana* (about 240 strokes) that were displayed in a monitor at random, by *romaji* (Japanese Roman characters) input and touch-typing.

3 Results and Discussion

3.1 Relation between Touch-typing Skill and Thinking-typing Speed

Touch-typing skill in Experiment 2 was divided into 4 levels under 1 minute (Level under 1 minute), between 1 minute and 2 minutes (Level of 1 minute), between 2 minutes and 3 minutes (Level of 2 minutes), between 3 minutes and 4 minutes (Level of 3 minutes). The mean and the standard deviation of thinking-typing speed in each touch-typing level are shown in **Table 1**. Thinking-typing speed in each subject was calculated by the next equation.

$$s = \frac{L}{T}$$

s Thinking-typing speed in each subject

L Typing linage in each subject*

T Time limit in each subject (minute)

*Number of letters per line, after *hiragana-kanji* translation, is 40.

Table 1. Touch-typing skill and thinking-typing speed

Touch-typing skill	Number of persons	Thinking-typing speed (linage/minute)					
		Shiritori		Imagination		Impression	
		M	*SD*	*M*	*SD*	*M*	*SD*
Level under 1 minute	6	1.13	0.25	0.65	0.16	1.07	0.14
Level of 1 minute	23	0.84	0.23	0.52	0.14	0.72	0.19
Level of 2 minutes	12	0.59	0.11	0.35	0.06	0.47	0.11
Level of 3 minutes	5	0.51	0.13	0.28	0.09	0.42	0.10
All the examinees	46	0.77	0.27	0.47	0.17	0.67	0.25

One-way analysis of variance was used to test for significant differences in thinking-typing speed among the 4 touch-typing levels. As a result, touch-typing skill had main effect in the 3 subjects(*Shiritori* $F=12.46$, $df=3$, $p<.01$ Imagination $F=11.31$, $df=3$, $p<.01$ Impression $F=23.55$, $df=3$, $p<.01$). What's more, Tukey's multiple comparisons test was applied to identify whether there are significant differences in thinking-typing speed among the 4 touch-typing levels or not. The results are shown in **Table 2**. Homogeneity subgroup is a group of similar levels whose difference is not significant. In the 3 subjects, there were significant differences of thinking-typing speed between the level under 2 minutes and the level over 2 minutes. These results show that reaching touch-typing level under 2 minutes in Experiment 2 was one of the conditions to type smoothly words or sentences appearing in the head.

Tabel 2. Tukey's multiple comparison of thinking-typing speed

	Touch-typing skill	Number of persons	Homogeneity subgroup		
			Gr1	Gr2	Gr3
Shiritori	Level under 1 minute	6	1.13		
	Level of 1 minute	23		0.84	
	Level of 2 minutes	12		0.59	0.59
	Level of 3 minutes	5			0.51
Imagination	Level under 1 minute	6	0.65		
	Level of 1 minute	23	0.52	0.52	
	Level of 2 minutes	12		0.35	0.35
	Level of 3 minutes	5			0.28
Impression	Level under 1 minute	6	1.08		
	Level of 1 minute	23		0.72	
	Level of 2 minutes	12			0.47
	Level of 3 minutes	5			0.42
	p .05	f			

3.2 Relation between Touch-typing Skill and Self-evaluation of Thinking-typing

Self-evaluation of Experiment 2 was divided into positive self-evaluation and negative self-evaluation to study the relation between self-evaluation and touch-typing skill. Positive self-evaluation is "very good", "good" and "a little good". Negative self-evaluation is "a little bad", "bad" and "very bad". As for self-evaluation point, positive self-evaluation is 1 point, and negative self-evaluation is 0 point. The mean of self-evaluation point of each touch-typing level is shown in **Table 3**.

Table 3. Touch-typing skill and self-evaluation

Touch-typing skill	Number of persons	Self-evaluation point					
		Shiritori		Imagination		Impression	
		Thinking	Typing	Thinking	Typing	Thinking	Typing
Level under 1 minute	6	0.50	1.00	0.17	1.00	1.00	1.00
Level of 1 minute	23	0.61	0.96	0.52	0.96	0.74	0.96
Level of 2 minutes	12	0.67	0.75	0.42	0.83	0.83	0.75
Level of 3 minutes	5	0.40	0.60	0.40	0.40	0.80	0.40
All the examinees	46	0.59	0.87	0.43	0.87	0.80	0.85

One-way analysis of variance was used to test for significant differences in self-evaluation point among the 4 touch-typing levels. As a result, touch-typing skill had main effect in the typing evaluation of imagination and in the typing evaluation of impression (typing evaluation of imagination $F=5.11$, $df=3$, $p<.01$ typing evaluation of impression $F=4.86$, $df=3$, $p<.01$). What's more, Tukey's multiple comparisons test was applied to identify whether there are significant differences about the typing evaluation of imagination and the typing evaluation of impression among the 4 touch-typing levels or not. The results are shown in **Table 4**. Typing evaluation of Level of 3 minutes in imagination was significantly lower than other touch-typing levels, and typing evaluation of Level of 3 minutes in impression was significantly lower than Level under 1 minute and Level of 1 minute. These results show that the students of Level of 3 minutes could not type smoothly imagination or impression, comparing with the students of other touch-typing levels.

Table 4. Tukey's multiple comparison of self-evaluation

	Touch-typing skill	Number of persons	Homogeneity subgroup	
			Gr1	Gr2
Typing evaluation of imagination	Level under 1 minute	6	1.00	
	Level of 1 minute	23	0.96	
	Level of 2 minutes	12	0.83	
	Level of 3 minutes	5		0.40
Typing evaluation of impression	Level under 1 minute	6	1.00	
	Level of 1 minute	23	0.96	
	Level of 2 minutes	12	0.75	0.75
	Level of 3 minutes	5		0.40

p .05 f

3.3 Relation between Learning of Touch-typing Skill and Change of Thinking-typing Speed

The mean of learning ratio of touch-typing skill and the mean of change ratio of thinking-typing speed in each touch-typing level of Experiment 2 are shown in **Table 5**. Learning ratio and change ratio were calculated by the next equation.

$$\alpha = \frac{T1}{T2} \qquad \beta? \frac{s1}{s2}$$

α Learning ratio of touch-typing skill
$T1$ Touch-typing time of Experiment 1 (minute)
$T2$ Touch-typing time of Experiment 2 (minute)
β Change ratio of thinking-typing speed
$s1$ Thinking-typing speed of Experiment 1 (linage/minute)
$s2$ Thinking-typing speed of Experiment 2 (linage/minute)

Two-way analysis of variance was used to test for significant differences in the 4 touch-typing levels and the 3 subjects about change ratio of thinking-typing speed in Table 5. As a result, main effect of the 3 subjects was significant($F=4.14$, $df=2$, $p<.05$). Main effect of the 4 touch-typing levels and interaction were not significant. What's more, Tukey's multiple comparisons test was applied to identify whether there are significant differences in change ratio of thinking-typing speed among the 3 subjects or not. As a result, there were significant differences of change ratio of thinking-typing speed between Subject 3 and other subjects. Next, correlation between learning ratio of touch-typing skill and charge ratio of thinking-typing speed is shown in Table 6. A moderate significant positive correlation was observed between learning ratio of touch-typing skill and change ratio of thinking-typing speed in Subject 3. So it can be said that learning of touch-typing skill is very effective on the increase of thinking-typing speed of Subject 3. What is the qualitative difference between Subject 3 and other subjects? It is the easiness of thinking. Thinking evaluation point in Table 3 expresses the easiness of thinking in each subject. Thinking evaluation point of impression (Subject 3) is higher than other subjects. So it is considered that words of impression (Subject 3) was easier to be thought out than other subjects. Therefore, it can be concluded that learning of touch-typing skill is very effective on the increase of thinking-typing speed of the subject that is easy to be thought out.

Table 5. Learning ratio of touch-typing skill and change ratio of thinking-typing speed

Touch-typing skill	Number of persons	Learning ratio of touch-typing	Change ratio of thinking-typing speed		
			Subject	Subject 2	Subject 3
Level under 1 minute	6	1.69	1.35	1.61	2.03
Level of 1 minute	23	1.58	1.24	1.47	1.93
Level of 2 minutes	12	1.57	1.18	1.57	1.61
Level of 3 minutes	5	1.50	1.89	1.47	1.80
All the examinees	46	1.58	1.31	1.51	1.84

Table 6. Correlation between learning ratio of touch-typing skill and change ratio of thinking-typing speed

	Change ratio of thinking-typing speed		
	Subject	Subject 2	Subject 3
Learning ratio of touch-typing	0.245	0.089	0.565**

**p .01 f

4 Conclusion

From what has been discussed about the relation between touch-typing skill and thinking-typing speed, and relation between touch-typing skill and self-evaluation of thinking-typing, it can be concluded that a touch-typing level under 2 minutes is necessary, at least, to type smoothly words or sentences appearing in the head. The speed of 240 strokes in 2 minutes equals 2 strokes/second. 2 strokes are needed to input a *hiragana*. So the speed of 120 *hiragana* in 2 minutes equals 1 *hiragana*/second. The aim of touch-typing education for thinking-typing should be set at 2 strokes/second (1 *hiragana*/second). What's more, from what has been discussed about the relation between learning of touch-typing skill and change of thinking-typing speed, it can be concluded that learning of touch-typing skill is very effective on the increase of thinking-typing speed of the subject that is easy to be thought out.

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A Virtual Classroom for Algorithms with Algorithmic Animation Support[1]

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A virtual classroom on algorithms with algorithmic animation and reference database supports is presented. The cognition of algorithms might need a process of individual thinking, iterative testing and experience sharing. Our virtual classroom offers learning aids on these respects via the web. The hypermedia courseware is designed to ease the navigation. A maintenance program is devised to automatically update the hyperlinks whenever the courseware is updated. Interactive algorithm animations are applied as knowledge construction assistance. It is expected that with visualization aids learners could demonstrate their comprehension of abstract algorithms. A reference database on algorithms is built up for both educational and research purposes. Studying communications such as self-testing, bulletin board, related web links, ..., etc., are also provided.

Keywords: **Multimedia and Hypermedia in Education (15), Virtual Classroom(19), Web-Based Learning(21), Algorithm Animations**

1 Introduction

The technologies of multimedia and networking on personal computers lead the research of computer-assisted learning into a new era in the last decade. Researches on the design issues of the hypermedia courseware recently please refer [17, 3, 4, 19]. Many evaluation studies also reveal positive results on learning via hypermedia courseware [7, 10, 12, 18]. With the popularity and maturity of hypermedia and web technologies, distant learning with a synchronous style via the web attracts many researchers' attention in both of the theoretical and practical points of view. The characteristics of such a web-based virtual classroom encourage the students to actively participate the construction of knowledge with their own pace and without the limitations of time and space. It is our aim in this paper to propose our design and implementation of a virtual classroom for studying algorithms with supports of interactive animations and a research paper database.

Material about algorithms is a core component for undergraduate degrees in computing. A major problem in teaching algorithms is the difficulty of capturing the dynamic movement of data and complicated data structures in static materials such as books and lecture notes [16]. Because different students learn at

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different rates, whatever pace the lecturer chooses will be wrong for some students. A virtual algorithmic classroom would be very crucial to assist students constructing their understanding with their own pace. Further, since the abstraction of algorithms might be challenging to learn and understand, it is hoped with graphical depictions the students' comprehension could be more effective and concrete. Thus we develop animations interactively by Java in our virtual classroom.

An algorithm animation is a dynamic graphical depiction of the data and operations of an algorithm. The animation purpose is to illustrate how the algorithm functions to someone seeking to learn the algorithm [15]. Researches concerning with the studies of algorithm animation or software visualization can be found on [9, 5, 13, 15, 14, 11]. A number of practical algorithm animation systems have been built over the last ten years. Some well-known systems include
BALSA [1], Tango [13], Zeus [2], AACE [6], Zeus (http://www.research.digital.com/SRC/home.htm0),
PAVANE and Opsis (http://swarm.cs.wustl.edu/pavane.html),
ZADA (http://ls4-www.informatik.uni-dortmund.de/RVS/zada.html), ...etc.
These systems typically have been used to create animations to accompany a lecture in an electronic classroom, or to prepare animations for students to observe and interact with outside the classroom. The updated technologies of multimedia tools and web programming and a complete hypermedia courseware helping students' comprehension make our algorithmic animations differ from theirs.

Besides the animations, in order to ease the tracing of the newest research results or referencing the related papers on algorithms, we built up a paper reference database to store research papers of algorithms, which can be queried and appended for educational or research purposes at the remote sites. We also provide some studying communication aids in a asynchronous mode such as self-testing, bulletin board, related web links, ..., etc., to improve the social communication among students in this virtual classroom.

The rest of this paper is organized as follows. The content of our algorithmic virtual classroom and the implementation result of our hypertextbook are presented in Section 2. The implemention of algorithm animations is illustrated in Section 3. The facility of the paper reference database is discussed in Section 4. Section 5 gives concluding remarks and future studying.

2 The Content of Our Algorithmic Virtual Classroom

There are four main themes in our algorithmic virtual classroom: (1) The Fundamentals of Algorithms, (2) Algorithmic Strategies, (3) Algorithmic Reference Database and (4) Studying Communications. Our design focuses on undergraduate students in science or management departments, while the database might have benefits for various kinds of users. The material is mainly based upon [8].

We re-organized the course material on algorithms as the hypermedia courseware (or hypertextbook) which helps the learners' actively exploring the knowledge. Each keyword (term or concept) on the web-courseware is linked onto its explanation page where the meaning is explained and all the links to the other occurrences in our courseware are also listed. A query facility for these keywords also provided. Consider that the course materials might be updated and the linkage relationships among keywords and their positions of occurrences on the web pages might also be changed. We developed a courseware maintenance program in C to automatically re-construct the linkage relation of all hyperlinks into its newest version whenever the courseware is updated. Figure 1 shows our hypertextbook on web. As the left frame shown in Figure 1, a tree-view browser is applied for learners to locate where he is in the courseware space. Figure 2 is the query result page of the keyword "insertion sort" which can also be reached by clicking "insertion sort" on the web content in Figure 1.

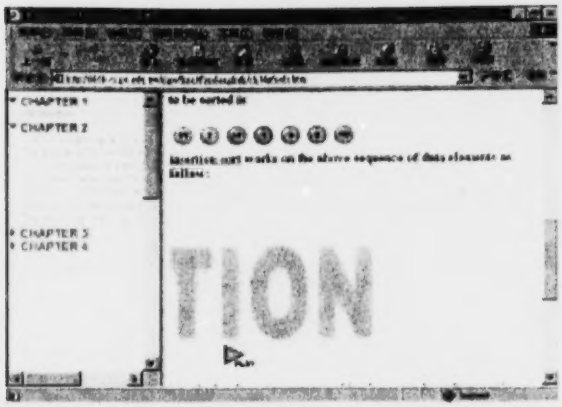


Figure 1 The web page format of our hypertextbook

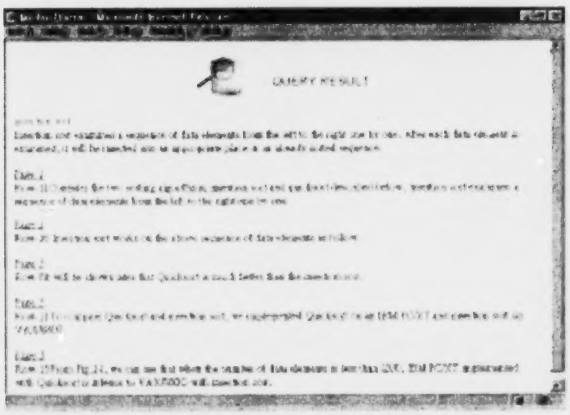


Figure 2 The query result of the keyword "insertion sort"

The content of the four main themes is described more in detail in the following sub-sections.

2.1 The Fundamentals of Algorithms

The content in this subject includes:

(a) Celebrity Hall: The contribution of some well-known computer scientists for algorithmic study such as D. E. Knuth, R. E. Tarjan, R. M. Karp, S. A. Cook, … etc, are introduced here.

(b)The Introduction of Complexity: The concept of complexity such as order, upper bound, lower bound, … etc, are explained.

(c)The analysis of computer algorithms: The analytic models of computer algorithms are explained. Proper examples are presented also.

All of the above materials are prepared as a web hypertextbook to ease the navigation.

2.2 Algorithmic Strategies

In current stage, three strategies are ready in our web classroom: greedy, divide-and-conquer and tree searching strategies. We not only construct the hypermedia courseware but also apply interactive animations as our learning assistants. Three interactively animated examples, i.e., solving the stamp problem, the minimum spanning tree via Kruskal's and Prim's algorithms respectively, are prepared for exploring the spirit of the Greedy method, while three, i.e., finding the maximum, quick-sort and merge-sort, interactive

animations are for Divide-and-Conquer and three, i.e., breadth-first-search, depth-first-search and hill-climbing, for tree searching. The implementation result is illustrated in Section 3.

2.3 Algorithmic Reference Database

It is most critical in almost every research areas, including of course the research of algorithms, to maintain a mostly updated reference database. We construct a web-based database via CGI technology to maintain those important references related to algorithms. Section 4 shows the implementation result in detail.

2.4 Study Communications

To increase the content of our courseware, we collect links of some important related web sites in our external-resource pages which enlarge the learners' view on the studying of algorithms. Meanwhile, to help students to self-evaluate the learning effect, self-tests are provided for learners to answer yes-no question sheets on the web. The system will score the result and give explanations automatically.

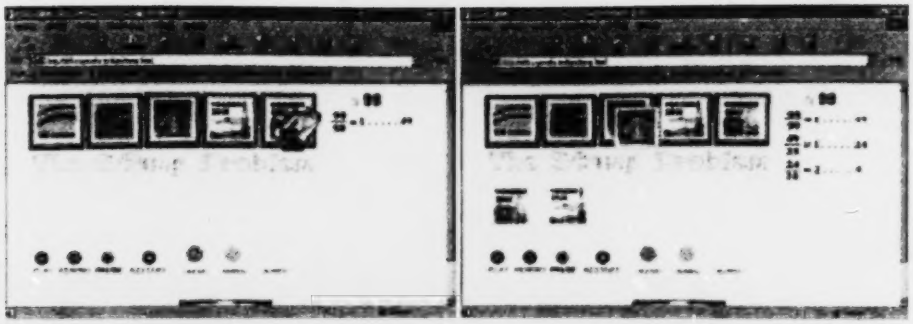
In order to improve the social communications for students in this asynchronous learning environment, we provide some interactive facilities:

(a)Bulletin board: This is an area for learners and teachers to post their idea, suggestions, questions, ...etc., on the web pages remotely. They could share the learning experience or learn from peers without the limitation of time or space.
(b)Paper up-loading: A web interface is provided for users to up-load their finding of new research papers on algorithms.

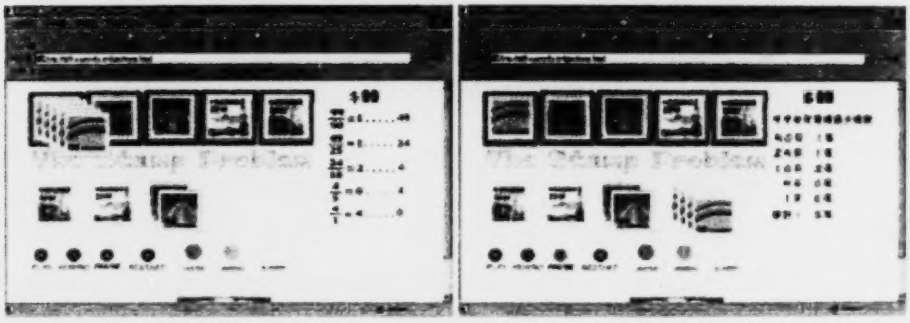
3 Interactive Algorithm Animations

Algorithm animations might be an effective tool for understanding the behavior and abstraction of algorithms. However, most approaches mentioned in Section 2 have focused on much sophisticated graphical depictions and not on the process of how learners construct their comprehensions via animations. As a way, two categories, static animation and dynamic animation, are considered in our virtual classroom. The former cannot be changed once built, while the latter might be changed according to some predefined parameters. We call the dynamic animation as interactive animation if the learners can assign values to those parameters in an on-line manner. The learners can choose either one to observe the actual data moving and to demonstrate their abstract concept. A control panel is provided for learners to control the running speed.

The static animations by Director offer multimedia presentations. Figure 3 illustrates an animated example of solving the stamp problem, which is to explain the greedy method. The interactive animations by Java allow the learners to change the animated results by assigning input variables with different values. Through observing the various running situations in terms to the given variables, learners can realize how those algorithmic steps are actually executed. It is expected that the conceptual cognition of these abstract strategies can be enhanced via the visualized running examples and the learners' comprehension could be more concrete. Figure 4 shows an example of merge-sort where the number of input instance can be assigned in an on-line manner.

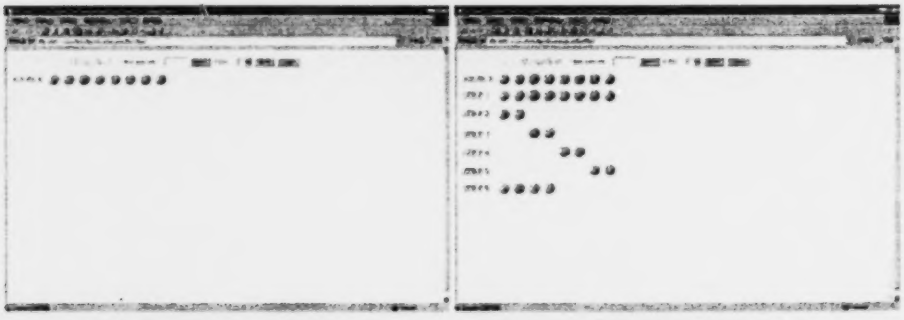


(a) the stamp with largest value is chosed (b) running with greedy

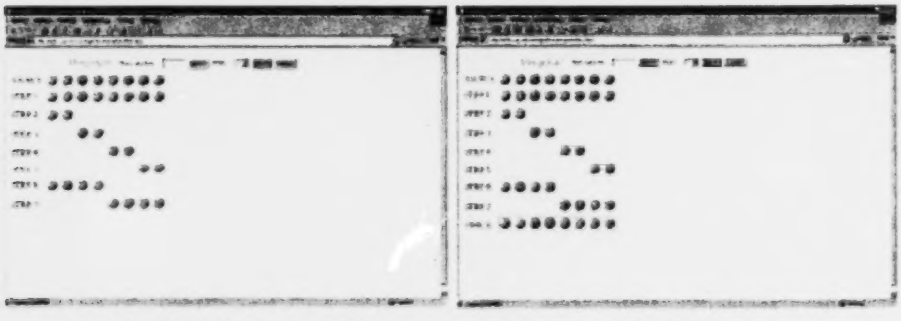


(c) running with greedy (cont.) (d) the final result

Figure 3 The static animation for the stamp problem



(a) input instance is assigned as 8 (b) the left half balls are sorted

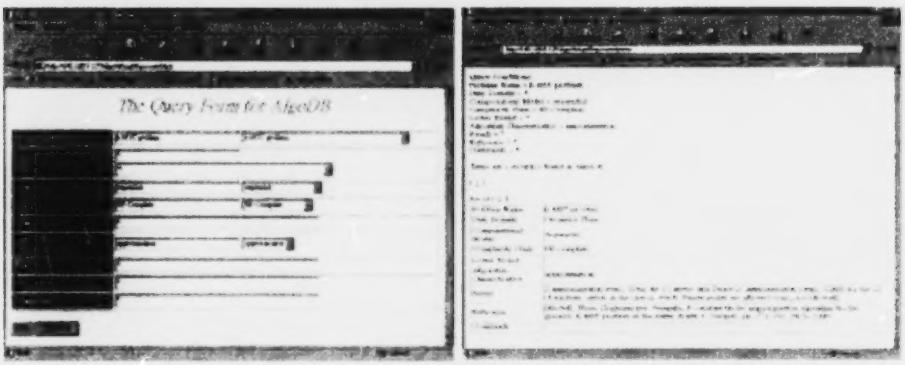


(c) the right half balls are sorted (d) the final result

Figure 4 The interactive animation for the merge-sort problem

4 Reference Database Support

To meet general researchers' requirements, it is designed to supporting query by using various fields such as: problem name, data domain, computational model, complexity class, lower bound, algorithm characteristics, result, reference and comments. It also supports the up-load functionality for interested researchers to up-load their new findings all over the world. This database is valuable not only for the researchers but also for students who could access the newest or related results at their interests. Figure 5 illustrates the query form, where k-MST problem with NP-complete complexity and other constraints are given, and the queried result of our reference database. This service would like to attract interested users' participation to our virtual classroom where discussions via the bulletin board are welcomed.



(a) a query form (b) the quried result

Figure 5 The query and result reference database on algorithms

5 Concluding Remarks and Future Studies

We propose the design and implementation our virtual classroom for algorithms in this paper. The cognition of algorithms might need a process of individual thinking, iterative testing and experience sharing. Our virtual classroom offers learning aids on these respects via the web. It is expected that such a learning environment could help students to learn algorithms more effectively at their own pace. The hypermedia courseware will be increased and updated as a long-term project.

The activities in the traditional classroom are simulated to a great extent in our virtual classroom. However, we are not intending to give up the face-to-face interactions. The authors applied this hypermedia courseware on web as a learning assistant in a part of this semester. Students showed interests on constructing their knowledge via the hypermedia courseware and animations. Some students expressed that they supposed to understand the recursion in quick-sort before feeding data to the interactive animation, however they found their misleading after the visualization of data movement in the animation. This is one of the benefits what we intend to give in this virtual classroom. The construction of the knowledge tree is underway to help tracing the learning pattern of learners. Also an empirical evaluation of the learning effect will be studied in the near future.

The reference database gradually gathers interested researchers' attention. The authors would express their special thanks to those who up-loaded their findings of new papers and those who gave valuable suggestions.

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An Adaptive Navigation Support with Reorganized Learning Resources for Web-based Learning

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On the Web, there are diverse learning resources with the same learning topic, each of which is designed by different authors. Properly using these web-based resources, learners can study the topic from diverse points of view. This is one of the prominent merits of web-based learning. However, learners would have difficulty in finding a learning resource suitable to their learning contexts because there are currently an enormous number of learning resources on the Web and because most web-based learning resources do not have a clear description of their characteristics such as what kind of learners should use, what kind of learning goal can be achieved. Our approach to this issue is to reorganize web-based learning resources with indexes called resource indexes representing their characteristics, and to provide learners with an adaptive navigation support, which recommends them some learning resources to be learned next in accordance with their needs and knowledge states. We also report a preliminary experiment to evaluate the validity of the adaptive navigation support with a demonstration system. From the results of this experiment, we have made sure that it is valid.

Keywords: **Learning Resource, Web-based Learning, Resource Index, Resource Navigation**

1 Introduction

Over the past several years, an increasing number of hypermedia/hyperdocuments based resources on the Web have been available, which are designed from an educational point of view, or which are worth learning. Learning with such existing web-based resources has accordingly become more important, particularly as the realization of lifelong and distance learning [1].

On the Web, there are many learning resources with the same topic, each of which is designed by different authors. Some of them are suitable for augmenting domain concepts/knowledge in the topic. Some are also suitable for having a deeper understanding of the topic with examples/simulation/illustration, or applying knowledge with exercises. Properly using these kinds of learning resources, learners can study the topic from diverse points of view. This is a prominent merit of learning a topic on the Web.

This paper describes a web-based learning environment that makes use of diverse learning resources involving a certain topic to promote learning. The main issue addressed here is how to help learners select some instructive learning resources according to their learning contexts. There are currently an enormous number of learning resources on the Web. In addition, most web-based learning resources do not have a clear description of what kind of learners should use, what kind of learning goal can be achieved and so on [7]. Learners consequently have difficulty in finding an instructive learning resource [4].

The approach presented in this paper is to reorganize web-based learning resources with indexes called resource indexes representing their characteristics, and to build a learning resource database. At present, there exist a number of Web sites collecting URLs of web-based learning resources. These sites use resource indexes, which mainly represent learning topics/subjects, to classify the learning resources. The resource indexes allow learners to know what they can learn beforehand. In other words, they can select learning resources from a "what to learn" point of view. However, the indexes are not enough for them to find a learning resource suitable to their learning contexts since they would usually think of not only "what to learn" but also "how to learn". They would particularly think of in which learning phase they try to learn. There are generally several phases of learning a topic such as augmenting new knowledge/information about the topic, deepening understanding of knowledge, applying/stabilizing knowledge, etc [5]. Which learning resource to select depends on in which phase learners try to learn. Learning phases should be accordingly represented as resource indexes.

In this paper, we propose a way to reorganize web-based learning resources with "how to learn" indexes (HTL indexes for short) including learning phases in addition to conventional "what to learn" indexes (WTL indexes for short), building a learning resource database. We also demonstrate an adaptive navigation support with the database, which recommends learners some resources to be learned next in accordance with their learning contexts such as needs and knowledge states. This aims to promote their learning from knowledge accretion phase to knowledge stabilization phase.

In the following sections, we first describe the way to build a learning resource database with WTL and HTL indexes. Next, we demonstrate the adaptive navigation support with the database. Furthermore, we report a preliminary experiment to evaluate the validity of the adaptive navigation support. From the results of this experiment, we have made sure that it is useful.

2 Reorganizing Web-based Learning Resources

2.1 Learning with Existing Resources on the Web

Before discussing the way to reorganize learning resources on the Web, let us first consider learning with them. In this paper, a learning resource means a hyperdocument, which describes a learning topic within a Web site. It provides learners with a hyperspace that consists of a number of Web pages. Learners can explore the hyperspace to learn domain concepts/knowledge [2], [6]. On the Web, in addition, there are diverse learning resources with the same topic, which could facilitate diverse learning phases such as augmenting and applying domain concepts/knowledge. Properly using these learning resources, learners can study the topic from diverse points of view.

As shown in Figure 1, we view web-based learning as learning a topic in three phases and as the transition between learning phases. The learning phases are as follows: accretion, understanding, and stabilization [3]. Each phase is also explained as follows:

- Accretion phase is the one in which domain concepts/knowledge are augmented;
- Understanding phase is the one in which known concepts/knowledge are understood with examples, simulations, illustrations, etc.;
- Stabilization phase is the one in which known concepts/knowledge are stabilized by means of problem-solving with exercises.

The transition between learning phases is expected to occur according to completion or impasse of learning in a phase. It is also expected to take place from knowledge accretion phase to knowledge stabilization phase or in the opposite direction. Learners' knowledge is finally expected to stabilize. However, learners need not always start learning from the accretion phase. They can start learning from any learning phase according to their knowledge states.

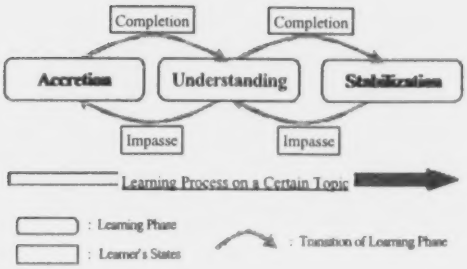

Figure 1 Web-based Learning

Table 1 Resource Index

WTL Index	Academic Year Subject Learning Topic	
HTL Index	Learning Phase	Accretion Understanding Stabilization
	Media	Texts only Graphics Animations Sounds Simulations E-Mail BBS, Chat Others
	Communication Channel	High Immediacy High Interactivit Questions and A

2.2 Resource Index

In learning a topic, learners would select a learning resource according to their knowledge states. However, most existing learning resources on the Web do not usually have a clear description about which learning phase could be facilitated. Therefore, the proper selection of learning resource is not so easy for them. One way to resolve this problem is to provide learners with a learning resource database.

There currently exist many Web sites, which collect URLs of web-based learning resources. In these sites, they are classified with resource indexes that mainly represent learning subjects/topics. These indexes allow learners to select learning resources from a "what to learn" point of view. However, such indexes are not enough for them to find a learning resource according to their learning contexts. When a learner wants to stabilize his/her knowledge of a topic, for example, he/she could select a learning resource suitable for augmenting knowledge about the topic. Learners would usually think of not only "what to learn" but also "how to learn" especially in which learning phase they should learn.

We have consequently provided resource indexes that consist of "How To Learn (HTL)" indexes in addition to conventional "What To Learn (WTL)" indexes, and have proposed a way to reorganize learning resources. In helping learners select learning resources proper for the transition between learning phases as shown in Figure 1, "learning phase" is first most important as HTL indexes. In helping learners continue learning in a phase, second, some HTL indexes are necessary for differentiating learning resources that could facilitate the phase. In fact, some learners may try to resolve an impasse, which occurs in one resource, with other resources that could facilitate the same learning phase. Considering web-based learning resources with the same topic, we can see various media for representing the contents such as text, diagram, chart, illustration, etc. We can also see various interactive/real time environments such as simulation, chat, BBS, etc. Such media and communication channels would have an influence on how to learn. In addition to learning phase, we accordingly regard them as HTL indexes as shown in Table 1.

2.3 Reorganization

Figure 2 shows how to reorganize learning resources with WTL and HTL indexes. First, the learning resources are classified with WTL indexes so that learners can see from a "what to learn" point of view. Next, the resources are classified with learning phases so that learners can select fom a number of learning resources with one topic. Some learning resources may have two or three indexes of learning phase. Finally, indexes of media and communication channels are attached to each learning resource as its attributes so that learners can select from a number of resources that could facilitate the same learning phase.

Following the above way, we have implemented a learning resource database where many existing resources have been indexed. We have also addressed the issue of how to support indexing (See [5] for more detail).

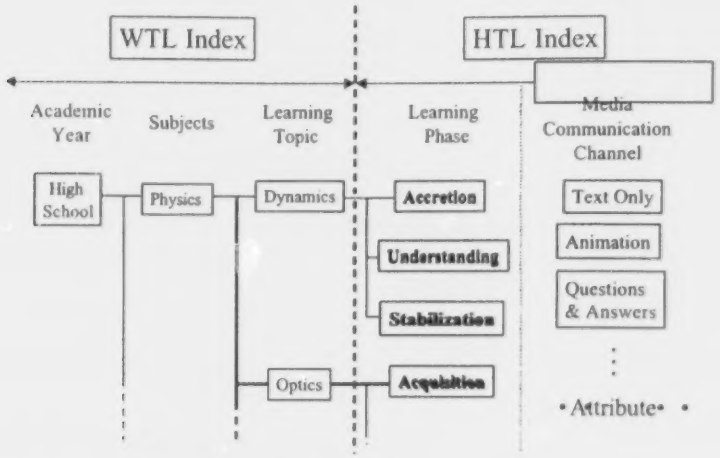

Figure 2 Hierarchy of Indexes

3 Adaptive Navigation Support

3.1 Learning Resource Navigation

Let us now introduce an adaptive navigation support with the learning resource database. Although the resource indexes allow learners to search learning resources they want to learn, it is still difficult for them to select a learning resource in accordance with their learning contexts to promote learning from knowledge accretion to knowledge stabilization. We have accordingly proposed a navigation support, which recommends learning resources to be learned next according to learners' knowledge states and needs.

The main aim of this support is to promote learning of a specific topic with diverse learning resources so that learners' knowledge can be stabilized. For this aim, in particular, it attempts to facilitate the transition between learning phases and to change media/communication channels for promoting learning in one phase. If a learner reaches an impasse in the understanding phase, for example, he/she is encouraged to return to the accretion phase to resolve it. If he/she completes the understanding phase, on the other hand, he/she is encouraged to move to the next phase that is stabilization phase. He/she is alternatively encouraged to continue learning in the same phase with different resources that have different media/communication channels.

3.2 Recommendation

Let us next explain how to execute the learning resource recommendation in accordance with learners' knowledge states and needs. In the navigation support, we consider two knowledge states: impasses and completion of learning a resource. Learners are asked which state they reach after learning the resource. If necessary, they can also demand change of media/communication channels for a learning resource to be learned next as their needs.

The learning resource recommendation uses the information given by the learners to make a list of learning resources to be learned next. The learning resources are put in the order of priority. The aim of the recommendation is not to give the learners the most instructive resource from the database. The list provides them with a guide in selecting instructive learning resources.

< Learner' s Input Window> <Resource Recommendation Window>

Figure 3 Resource Navigation System Interface

Figure 3 shows the interface of the prototype system for adaptive navigation support. This system, implemented with Common Gateway Interface (CGI), consists of two windows. The left window enables learners to input their needs and knowledge states in learning the current resource. It also shows a history of learning resources used, and encourages the learners to reflect on their learning processes. The right window displays a list that puts learning resources in order of priority for recommendation.

3.3 Procedure

Let us next explain how to decide the order of priority for recommending learning resources to be learned next. It corresponds to deciding which resource indexes should be given priority.

3.3.1 Ordering with Knowledge States

(1) Case of Impasse

When learners reach an impasse in a learning phase, learning resources, which could facilitate the previous learning phase, are first recommended so that they can resolve the impasse. The previous phase as index is accordingly given priority. On the other hand, the next phases are not given priority. Learning resources that have the same media/communication channels are also recommended since the learners may get confused with a change of media/communication channels in addition to the change of learning phase. The same media/communication channels as indexes are accordingly given priority. In case learners' knowledge state is in an impasse, therefore, learning resources that have the previous phase and the same media/communication channels as resource indexes are recommended as resources that are more instructive.

(2) Case of Completion

When learners complete learning in a learning phase, learning resources that have the next phase as index are first recommended so that they can further their knowledge. The next phase as index is accordingly given priority. The previous phases, on the other hand, are not given priority. The media/communication channels as indexes are given in the same way as the case of impasse. In case learners' knowledge state is in completion of learning, therefore, learning resources that have the next phase and the same media/communication channels as resource indexes are recommended as resources that are more instructive.

3.3.2 Ordering with Learners' Needs

In learning a resource, some learners may demand change of media/communication channels for the learning resource to be learned next. Regardless of learners' knowledge states, in this case, the same learning phase and different media/communication channels as indexes are given priority. The same media/communication channels are not given priority. Second, the different learning phases as indexes are not given priority according to learners' knowledge states. In case of impasse, the next phases are not given priority. In case of completion, the previous phases are not given priority. Learning resources that have the same phase and different media/communication channels as resource indexes are consequently recommended as resources that are more instructive. However, the way of ordering discussed in 3.3.1 is executed if learners reiterate learning in the same phase.

3.3.3 Calculation for Recommendation

Let us explain the way of calculation for ordering learning resources with an example. Learning resources are ordered with recommendation score, which is calculated every resource. Each learning resource has a number of HTL indexes. The recommendation score is calculated as follows. It is first scored ten points per learning phase index that is given priority, and is scored minus ten points per learning phase index that is not given priority. Next, it is scored one point per media/communication channel index that is given priority, and is scored minus one point per media/communication channel index that is not given priority. The larger the recommendation score is, the higher the priority of recommendation is.

Figure 4 shows an example of ordering five learning resources. In this example, a learner inputs "impasse" as his/her knowledge states in learning a resource. The learning resource has the "understanding" phase, "text only" media as HTL indexes. In this case, the accretion phase as index is given priority. The stabilization phase is not given priority. In addition, the "text only" media as indexes is given priority, while the other media/communication channels are not given priority. Therefore, the recommendation scores for the five learning resources calculated as shown in the right side of Figure 4. The learning resource that has the accretion phase and "text only" media as HTL indexes is recommended in the highest priority.

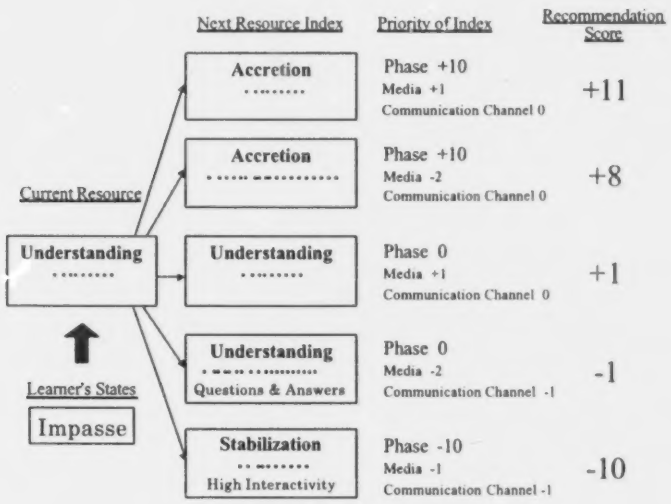

Fig. 4 Example for Recommendation

4 Preliminary Evaluation

4.1 Experiment

In order to evaluate the adaptive navigation support with the resource indexes and the learning contexts, we have had a preliminary experiment. The main purpose of this experiment was to ascertain the validity of the way of calculation for the recommendation order.

In this experiment, we compared the order of priority for recommendation generated with the adaptive navigation support to the order in which subjects placed learning resources by reading them carefully. Table 2 shows learning resources used in the experiment, which are described about a learning topic of "Global Warming Issue". Subjects were 12 graduate and undergraduate students in department of engineering. In spite of a well-known topic, the results of pretest indicated that they did not necessarily have sufficient domain knowledge.

The procedure of the experiment with each subject was as follows:
(1) He/she was asked to learn the resource A and then to input his/her knowledge state after learning. If he/she wanted to change media/communication channels, he/she could also input it as his/her need.
(2) He/she was asked to read the remaining resources carefully and place them in the order where he/she felt them more proper for his/her knowledge state and need.

Table 3 shows the order of priority for recommendation in each learning context considered. The order is calculated by the way discussed in section 3.3. For example, the recommendation is done in order of resource C, B, D and E, when a subject's knowledge state is in completion. Comparing the order of priority for recommendation to the order that subjects decided, we evaluated the validity of the learning resource recommendation.

4.2 Result

Table 4 shows the results of this experiment. The vertical axis is the order in which the system placed the learning resources (System-decided Order for short) and the horizontal axis is the order in which subjects placed them (Subjects-decided Order for short). The smaller the number of the order is the higher the priority for recommendation is. Each value in the table means the number of cases that fulfilled the System-decided order and the Subjects-decided order. For example, there were six cases where both System-decided and Subjects-decided orders were the first place.

In order to look into an approximate tendency in Table 4, we divided the order of priority into High and Low. As shown in Table 5, the High order including the first and second places of both System-decided and Subjects-decided orders, and the Low order also including the third and fourth places. We then performed Fisher's exact probability test in Table 5. As a result, there was a significant relevancy between System-decided order and Subjects-decided order($p=0.00867$), and these orders were positively related with a correlation ($\bar{o}=0.42$). It indicates that System-decided order agreed with Subjects-decided order approximately.

Table 2 The Learning Resource for Experiment

	Resource	HTL Index
A	Think about global warming http://www.nature-n.com/g_wrm/index-j.htm	Phase : Accretion Media : Graphics
B	Eco-Life Guide • The Issue of Global Warming http://www.eic.or.jp/ecolife/t001.html	Phase : Understanding, Stabilization Media : Graphics, Others Communication Channel : Questions
C	Kyoto-Earth's Homepage • Environment• Global Warming http://www.pref.kyoto.jp/intro/21cent/kankyo/h3.html	Phase : Accretion, Understanding Media : Graphics, E-Mail
D	Global Warming http://www.wnn.or.jp/wnn-eco/cop3/index.html	Phase : Accretion, Understanding, S Media : Graphics, Others Communication Channel : Questions High Interactiv
E	Tackling to the global environmental problems • Global Warming http://www.epcc.pref.osaka.jp/apec/jpn/earth/index.htm	Phase : Accretion Media : Graphics

Table 3 Order of Priority that the System Ordered

Case of Completion

Resource	Priority			Or
	Phase	Media	CC	
B	+1	+1,-1	-1	
C	+1	+1,-1	0	
D	+1	+1,-1	-1,-1	
E	0	+1	0	

Case of Impasse

Resource	Priority			Or
	Phase	Media	CC	
B	-1,-1	+1,-1	-1	
C	-1	+1,-1	0	
D	-1,-1	+1,-1	-1,-1	
E	0	+1	0	

Case of Change (State : Completion)

Resource	Priority			Or
	Phase	Media	CC	
B	0	+1,-1	+1	
C	+1	+1,-1	0	
D	+1	+1,-1	+1,+1	
E	+1	-1	0	

Case of Change (State : Impasse)

Resource	Priority			Or
	Phase	Media	CC	
B	-1,-1	+1,-1	+1	
C	+1,-1	+1,-1	0	
D	+1,-1,-1	+1,-1	+1.+1	
E	+1	-1	0	

(CC : Communication Channel)

Table 4 Result of Experiment

System-decided Order	Subjects-decided Order			
	1	2	3	4
4	2	1	4	5
3	1	3	3	5
2	3	3	4	2
1	6	5	1	0

Table 5 Result of Experiment

	Subjects-decided HighOrder	Subjects-decided LowOrder
System-decided LowOrder	7	17
System-decided HighOrder	17	7

5 Discussion

From the results of the experiment, we have made sure that the adaptive navigation support is useful for learners to learn a certain topic with diverse learning resources. However, it does not work well for learners who cannot input their knowledge states and needs by themselves because these are important information for the adaptation. One way to resolve this is that teachers/instructors help such learners input. In addition,

some learners may input their wrong knowledge states. However, this is not a serious problem from a whole learning process point of view since inputting "completion" as knowledge state despite his/her incompleteness of learning would cause a serious impasse in the next learning phase, for example. Alternatively, inputting "impasse" despite his/her completeness of learning as knowledge state would cause a complete learning in the previous phase without difficulty.

Lets us next discuss the adaptive navigation support compared with related work on courseware generation on the Web [8]. Courseware is generally generated in order to facilitate learning of a series of topics and relationships between these topics. Each topic included in a courseware accordingly needs to be designed as learning resource from a specific point of view. In related work on courseware generation, the same designer prepares each learning resource for each topic on the Web. However, it is hard to make a courseware from existing web-base resources since they are usually designed from different points of view. On the other hand, we focus on properly using diverse resources with the same topic, not with related topics, to promote learning of it from diverse points of view.

6 Conclusions

This paper has proposed a learning resource database that reorganizes learning resources on the Web with resource indexes. This paper has also presented the adaptive navigation with the database, which recommends learners some resources to be learned next according to their needs and knowledge states. This allows learners to use existing learning resources with a certain topic to promote their learning. In addition, the paper preliminarily evaluated the adaptive navigation support. In this experiment, we compared the order of priority for recommendation generated with the adaptive navigation support to the order in which subjects placed learning resources. As a results, we have made sure that it is valid.

In the future, it is necessary to evaluate the adaptive navigation support in more detail. We would also like to develop a more practical system and open to the public.

Acknowledgments

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An Empirical Study of the Design and Use of a Multimedia Composition-Making System for Children

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In this paper, we describe our experiences in designing and using a multimedia composition-making system for children. The system allows children to make compositions using pictures, sounds and text. Moreover, it also allows pictures in the composition to be animated. We experimented with children using this system in three different settings. In the first setting, no topic was assigned to the children. In the second and third experiments, children were given a topic (different for each experiment) for composition related to their activity. We present here the results of our experiments and comment on how the constraints imposed by the topic affect children's expressive abilities.

Keywords: **animation, children's expressive abilities, constraints and creativity, multimedia composition.**

1 Introduction

In recent years, many researchers have studied multimedia techniques and have incorporated them into various educational systems. For example, Silva [5] described a multimedia soundscape system, "They Are Catching Sounds in the Park!", for environmental education. In this system, children search for sounds by clicking anywhere in the picture. When they click an appropriate object, its associated sound and information are presented to the children. Brna [1] proposed a system for composing and writing stories via cartoons. Harviainen [2] presented a co-authoring system in which many users work together to compose a story. Ishii [3] and Kawakami [4] have developed other systems for making stories with multimedia. All this research demonstrates that multimedia has much potential for stimulating the ability of children to express themselves. In particular, we find that children can express their creative and imagined ideas much better with pictures and words than with words alone. Moreover, if we add an ability to attach sounds to pictures, and allow pictures to be animated, then this expressive power increases considerably.

Motivated by these factors, we have developed a system to help children write multimedia compositions, and have tested it with children in three different settings. In this paper, we describe our system and report on our experiences with children using the system.

2 Prototype of the System

We developed a prototype of a multimedia composition-making system. Using our prototype,

- Children can express their thoughts and ideas via pictures, sounds, text, and animation sequences. In our system, children must first choose a background scene, in which they can then insert picture objects, sounds, and text.
- Except for the background, children can attach sounds and text to picture objects, and can animate them to make a multimedia composition.

This system has two modes: a ' Set up' mode for the teacher or supervisor to allow them to determine which background scenes, picture objects, sounds, etc. are made available to the children for writing a composition,

and a ' User' mode for children to write compositions.

The ' Set up' mode has the following two functions:

1) Select situation: Set the context or theme for the composition.
2) Edit situation: Set the categories of background scenes, picture objects and sounds corresponding to a theme.

The ' User' mode has the following seven functions:

1) Select background scenes.
2) Select picture objects.
3) Select sounds.
4) Write text.
5) Animate composition.
6) Save composition.
7) Load composition.

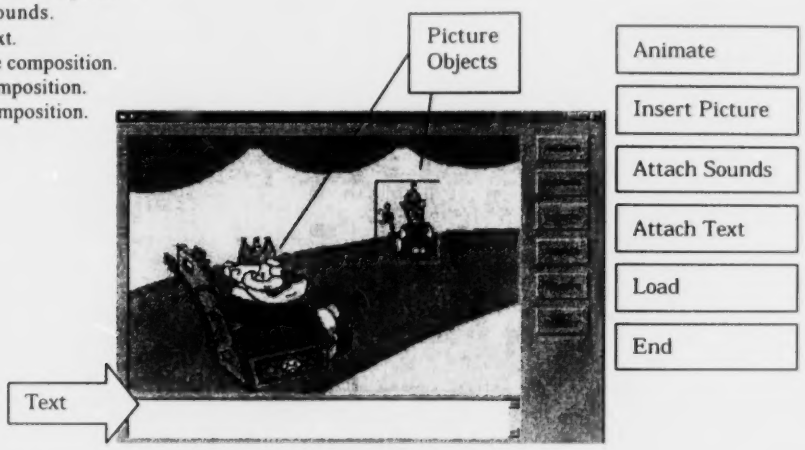

Figure 1. An example of the main window

By double clicking on a picture in the main window, the sound attached to that object (if any) can be heard. Also, when the picture of an object is selected in the main window, the text attached to it is displayed in the text box.

The animation module has five functions: show picture, hide picture, output sound, show text, and move picture.

To replay animation, children click the 'start' button in the animation window. When the button is clicked, the system starts the animation sequence as previously specified. It replays each action one by one, but it pauses when the action is ' show text' . To continue from there, the user needs to click the ' start' button again.

3 Experiments with the system

We did three different experiments in which children used our system. In each experiment, the setting and the tasks given to children were different, as described below.

3.1 Experiment I

In this experiment, we studied a constraint-free use of the composition system. The children were not given any specific topic of composition, and they could use the system any way they like to create any composition freely. We prepared 54 background scenes, 185 pictures and 68 sounds. Because no topic was given, children chose a variety of themes.

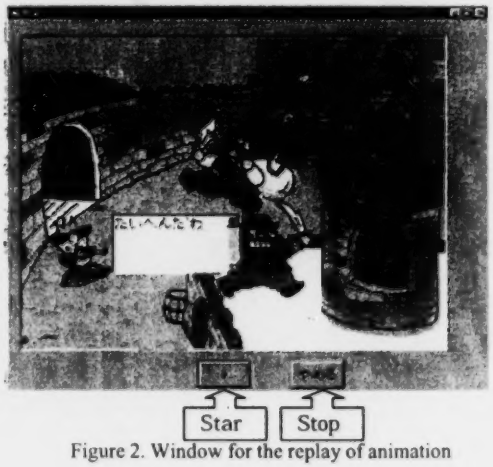

Figure 2. Window for the replay of animation

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3.2 Experiment II

In this experiment, we introduced a constraint by giving a topic of composition to the children, and analyzed the generated compositions. The experiment was done at an activity center for children. At this center, children of each grade come periodically, and play or make some handicraft. One of the handicraft projects for third-grade children was making kites. So, the following week, we asked the children to make a composition about kite making. For the experiment, we prepared a version of the system with six backgrounds scenes of craft rooms. Three of these were scenes with kites in them, and the others were scenes with only a room and tables without kites. We also prepared 68 pictures and 35 sounds appropriate for kite-making activity.

3.3 Experiment III

In this experiment, we introduced a tighter constraint by giving a more specific topic of composition to children, and studied its effect. We asked the children to make a composition for the story "The coward king and robber" (original title in Japanese). The original story is written in Japanese. At the same activity center for children used in Experiment II, the children made an extended version of this story, made a picture book to illustrate various scenes in the story, and then told the story using these pictures at their Christmas party. The week following the party, we asked the children to make a composition for this story using our system.

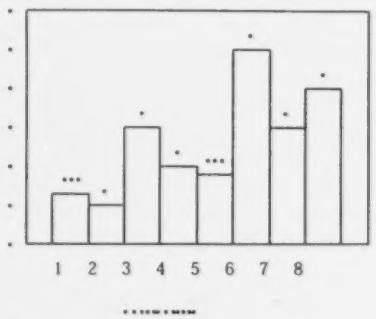

Figure 3. Differences between the composition picture and the original picture from the picture book (for each background scene)

For this experiment, we prepared a version of the system with eight background picture scenes related to the story. We also prepared 66 picture objects and 33 sounds appropriate to the story.
In this experiment, we were interested in analyzing the differences between compositions made using our system and the corresponding pictures in the picture book for this story that the children had made earlier. We used the following method for computing the difference. The picture objects were grouped into ten categories, and the difference between two pictures (with the same background scene) was calculated as follows:

> For each picture object category: if there is an object of that category in both the pictures, we say that the difference between the two pictures with respect to that category is zero. If one picture has an object from that category, and the other has none, we say that the difference with respect to that category is one. The difference between two pictures is the sum of the differences over all ten categories.

Figure 3 shows the result of applying this procedure.
We see that the differences for the climactic scenes (scenes 6• 7) are higher than the other scenes.

3.4 Discussion

An analysis of the compositions produced in the three experiments is shown in Tables 1, 2 and 3. Table 1 shows the average number of compositions produced by a participant in each experiment. We see from it that the children were most expressive when the topic was most constrained (Experiment III).

Table 1. Number of compositions per participant

	Experiment I	Experiment II	Experiment III
Number of participants	11	7	5
Number of compositions per participant	1.3	1.4	4.6

Table 2 shows a more detailed analysis of compositions with respect to how multimedia features of the system were used.

Table 2. Number of multimedia features per composition

Multimedia feature	Experiment I	Experiment II	Experiment III
Picture objects	3.6	11.2	6.9
Sound attachments	1.1	2.4	1.6
Text attachments	-	1.1	1.6
Animation	1.0	2.8	9.9

Here we see that picture and sound attachments are used most in Experiment II. This may be because in this setting children were describing a situation using generally one page (screen). For this, they used many objects and sound attachments to provide information about the depicted situation. We also see that text attachments and replay actions were used most in Experiment III. It might be because in this setting they were describing a story, for which text attachment is a useful way to express characters' utterances, and animation is useful to express characters' movement. We also would like to point out that in Experiment III there were fewer picture objects and sound attachments per composition. This is because to show the flow of events in the story, children made many compositions (Table 1).

Table 3. Analysis of animation operations per composition (in percent)

Animation operation	Experiment I	Experiment II	Experiment III
Show picture	0	0	53
Hide picture	0	0	4
Output Sound	13	0	10
Show text	-	0	15
Move picture	87	100	18

In this table we see that in Experiments I and II, mostly the 'move picture' operation was used. In composing a story, however (Experiment III), the 'show picture' was used most. We also found that the 'hide picture' operation was rarely used.

4 Conclusions

From our experiments, we see that the multimedia features of the composition-making system are most useful in illustrating a story or a narrative. Sound and text attachments and animation operations can be very helpful in expressing movement of characters and the progression of events in a narrative. We also found that many children are most expressive when they are given a focus of composition.

From these results, we propose that a system such as ours can be used in the classroom for children to make compositions about field trips and class excursions. For each trip or excursion, the teacher can set up the system appropriately by choosing relevant picture and sound libraries before children use the system. In this way, we feel that our system can provide a step forward from Silva [5]. Children are more actively involved in making compositions with our system than in exploring with 'They are catching sounds in the park!"

Acknowledgements

We would like to thank all the children who participated in the experiments, and the staff at the children's center for their cooperation. We thank Professor Yoshiyuki Kotani, and members of the Kotani-lab for their help and cooperation during this research. Some pictures used in the background of Experiment III were taken from [6].

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Automated Quantitative Extraction Method of Aesthetic Impression from Color Images using the Tone in the HLS Muncell Color Space

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The students acquire a visual literacy through learning the coloring systematically in the fine arts subject. This paper describes an extraction method for the aesthetic impression of the paintings based on the tone in the Muncell color space for fine arts subject. The impression, which the human being gets from the paintings, depends on the motif, the composition and the coloring. Here, we discuss the evaluation method of the paintings by the computer based on the tone that includes the lightness (intensity) and the saturation (vividness). We perform the evaluation experiment of the paintings that have a unique coloring. The evaluation result approximately resembles the impression of which human being is moved. This method is also useful for retrieving the image database using the ambiguous key words like the impression words.

Keywords: **aesthetic impression of paintings, color tone, color harmony, visual literacy, fine arts subject, image retrieval system**

1 Introduction

Fine arts subject educates the ability of the sense beauty, that is, a visual literacy through recognizing a form and a color. For training such a visual literacy, it is important for the students to understand the nature of color systematically. Visual literacy that is the aesthetic judgment ability becomes the basis of the expression and the appreciation activity in the fine arts learning. The students acquire the visual literacy by experience through repeated practice of painting the picture. On the other hand, there are the empirical rules about the composition and the coloring in the art. As for the color harmony, Ostwald, Muncell and Moon Spencer are well known.

Recently, the multimedia database spreads widely with the development of the network technology. In the multimedia database retrieval, it is useful that we can refer database using the impression words and the ambiguous feeling words in addition to the key words. Recently, an image database retrieving by impression words as beautiful, balmy is reported [1-5].

We report the extraction way of the aesthetic impression degree of the paintings based on the Moon Spencer's color harmony theory [6]. However, in the Moon Spencer's way, we can estimate the degree of the beauty as the numerical value but we cam not know the detail impression like the dark, light, bracing impression which each painting gives. In this study, we describe more concretely the way of extraction the aesthetic impression of the paintings based on the tone in the HLS Muncell color space.

2 The tone and the systematic color names

We call a suitable coloring the color harmony. In the color harmony theory, Ostwald, Muncell and Moon Spencer are well known. Also, a color system is established by JIS (Japanese Industrial Standards) and

PCCS (the Japanese Color & Coloring System).

Here, we use the tone in the Muncell HLS space for estimating the impression of the paintings more precisely. We express a color by the word, which shows the impression of the color like the light green, the dark green. There is a difference between bright and dark, strong and gentle, vivid and muddy in the same color, same hue. We call this difference the tone (Lightness and Saturation). The tone is a concept of the lightness L and the saturation S being compounds and shows an impression of the color, which doesn't depend on the hue well. As the tone has an each image, it is easy to connect the tone the psychological effect of the color. We can evaluate the feeling impression of the paintings by extraction the tone from the image data. In this paper, we adopt the PCCS tone for evaluating the impression of the paintings [7]. The PCCS defines the tone in the lightness L and the saturation S in the Muncell color space and gives color system as the tone and the hue. The PCCS classifies into 12 kinds of tones in each hue and packs the same tone of the every hue. Figure 1 shows the classification of the tone.

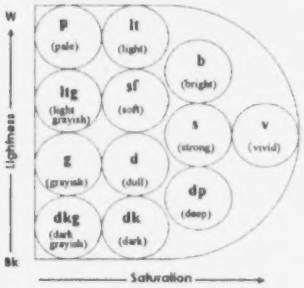

Figure 1 Tone (Lightness – Saturation)

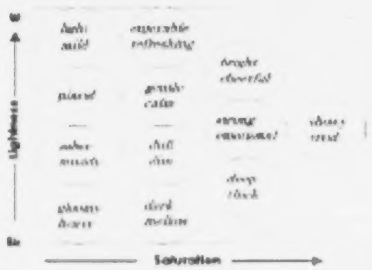

Figure 2 Systematic Color Names

The tone image is defined by the systematic color names in the PCCS color system. The systematic color names is the color expression way that gives a modifier according to each fundamental color like white, red and blue. It sets a way of combining a fundamental color name and modifier. The modifier in PCCS includes an adjective, which shows the hue difference like the tinge of red, green. On the contrary, it has no word, which shows only lightness or a saturation. The bright impression includes not only the high intensity but also the vivid saturation. The mild impression means the high lightness and low saturation. Figure 2 shows the systematic color names of the tone space.

3 Evaluation of the aesthetic impression

After getting the image data through the scanner, we extract the impression feature of the paintings. Figure 3 shows the outline of our method. The resolution and the size of the image data is 120 [pixels/inch] and 640*512 [pixels] respectively. The image data is a full color, bit map.

The image data has RGB color component and doesn't connect with the color sense of the human being straight. Also, it is difficult to adjust the color tone in the color synthesis. Here, we convert the RGB to the HLS value in the Muncell color space, which fits for the color sense of the human being. Mucell color system shows the color as the three components, H (Hue), L (Lightness) and S (Saturation) and is used widely in the coloring. Figure 4 shows the Muncell HLS color space. We get the H[0,360], L[0,1], S[0,1] values through the conversion of the RGB[0-255] value.

The number of the colors in the image data is enormous for processing data by a computer. Here, we reduce the number of colors to the degree, which doesn't loose the color tone of the paintings. We divide the H, L and S to 10 and 14 respectively.

Hue (H)	Lightness (L)	Saturation (S)
R	8.5	14
YR	9	13.5
Y	9	13
GY	9	12
G	8.5	11
BG	8.5	10
B	8.5	10
PB	8	11.5
P	8	11.5
RP	8.5	12.5

Table 1 Maximum Values of L, S

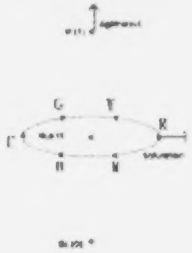

Figure 4 HLS Muncell Color Space

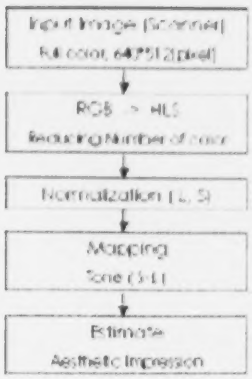

Figure 3 Outline of the Extraction Process

The maximum value of the L and the S depends on the coloring material and each hue shown in table 1. Therefore, the value range of the L and S is different according to each hue. For example, the maximum L, S value of the Red and Purple hue is 8.5, 14.0 and 8.0, 11.5 respectively. Here, we normalize the L, S value 0-10 ranges.

From the above way, we estimate the number of the pixel in the S-L tone space through mapping the image data to the tone space. We can find the aesthetic impression of the paintings by estimating the position of the mapped pixel in the tone space because of the correspondence between the tone space and the impression modifier shown in figure 2. In this experiment, we evaluate the number of the colors, which accounts for 70 % of the color area. However, we cannot estimate the impression because the distribution in the tone space becomes apart. Here, we calculate one position of the tone space from several distributed positions using the weight coefficient of each tone position.

$S = W_i S_i \qquad L = W_i L_i \qquad (1)$

Where $Wi = \sum(a_i / \sum a_i) \square a_i$ is the number of the occupied pixel in each color.

We estimate the impression of the paintings according to the tone index (S, L) defined in equation (1).

4 The evaluation experiment

The simple coloring picture is tested beforehand. As a result, the showy picture of the pure color and the gloomy picture are mapped over the v (vivid) and dkg (dark grayish) tone respectively. Typical paintings and poster works from renaissance to modern are tested in this experiment shown in table 2. Figure 5 and figure 6 shows examples of the paintings and the typical mapping result in the tone space respectively. We can evaluate the aesthetic impression of the paintings using figure 6 and figure 2. The extraction impression is listed as follows.

"Mona Lisa" (2) of Leonardo da Vinci is famous for gently smiling lady. This painting locates near dk (dark) in the tone and gives dark, mellow impression.

Monet's "Water Lily" (5) is said the mystic beauty of the surface of the water and is situated on the tone space near ltg (light grayish). We can say that the water lily has a cooled silent image.

Gogh's "Sun Flower" (8) is painted yellow strongly which he liked most. It is situated on the tone space near s (strong). From this result, we can evaluate that the impression of sunflower is strong, passionate painting.

Figure 7 shows the mapping result of the works in table 2. The above-mentioned results agree with the established reputation and the eye inspection of human being.

Table 2 Lists of Paintings and Design Pictures

	Painter	Style	Work	epoch
1	Leonardo da Vinci	Renaissance	Virgin of the Rock	1503
2	Leonardo da Vinci	Renaissance	Mona Lisa	1503
3	Rembrandt	Baroque	Night Watch	1642
4	Rembrandt	Baroque	Raising of the Cross	1633
5	Monet	Impressionist	Water Lilies	1903
6	Monet	Impressionist	Flower Pot	1903
7	Monet	Impressionist	Poplas	1873
8	Gogh	Modern	Sun Flowers	1888
9	Gogh	Modern	Self Portrait	1889
10	Signac	Impressionist	Saint-Tropez	1900
11	Renoir	Impressionist	Theater Box	1874
12	Renoir	Impressionist	Les Grands Boulevards	1880
13	Renoir	Impressionist	La Liseuse	1876
14	Klee	Modern	Baldegrain(Seaside)	1922
15	Matisse	Modern	Green Stripe	1905
16	Matisse	Modern	Red Room	1947
17	Munch	Modern	Scream	1893
18	Munch	Modern	Sick Child	1895
19	Poster	Design	Star Wars	
20	Poster	Design	Bug's Life	

Figure 5 Examples of the paintings

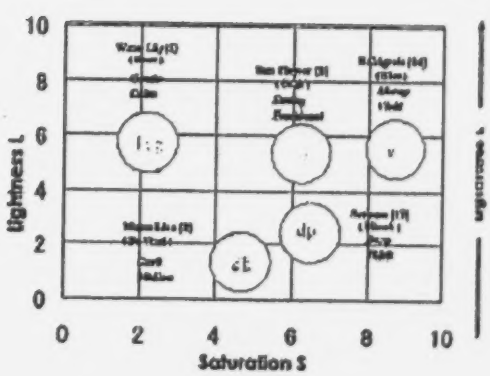

Figure 6 Mapping Result in the Tone (1)

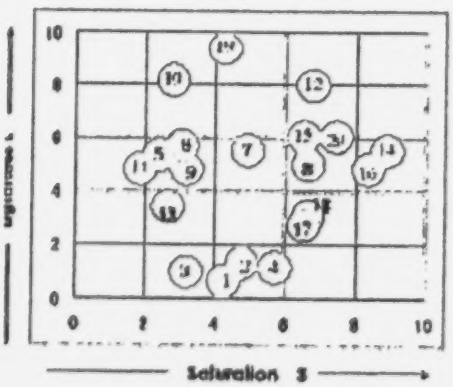

Figure 7 Mapping Result in the Tone (2)

5 Conclusions

We proposed the way of evaluating the beauty and impressive sense of the paintings and design pictures based on the tone in the Muncell color space. We use the tone space, which can concretely express the color impression and a corresponding systematic color names. This method suits the aesthetic impression degree evaluation by the computer because the evaluation processing doesn't depend on the hue.

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After getting the image data through the scanner, we convert each RGB pixel the tone space in HLS Muncell color space. We extract the location of the paintings in the tone space by calculating the coefficient of the occupied area. The aesthetic impression is estimated by the location of the used color in the tone space.

The famous paintings from renaissance to modern are tested for extracting the impression feeling. "Mona Lisa" of Leonardo da Vinci and Gogh's "Sun Flower" is estimated as matured darkly and strongly passionate impression respectively. These results tell us that the distinction by the computer coincide with an established reputation of the paintings.

The impression extraction by this way is useful for the students learning how to use color arrangement in their fine arts subject.

Acknowledgments

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Building the Multi-tier Architecture of Component-Oriented Multimedia CAI Systems on Internet

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The popularity of WWW (World Wide Web) produces lots of new instructions or substitutive cases to build a new future, therefore educational units need to develop various computer-assisted instructions. To ensure good learning effect, the instructive strategy adopted by most CAI systems is to provide tremendous amount of multimedia data in order to attract the learner and a complete process of instruction is like the scenario of a presentation. The purpose of this thesis is to discuss how the multi-tier developing architecture can let the multimedia learning resources be used and shared in WWW from a view of organization's requirements, such that teachers, measuring researchers, and learning researchers can perform different tasks according to their own specialties independently. We also propose and implement a multimedia presentation system to let various authors with various identities author and present their presentation, i.e. CAI systems, conveniently and correctly. We compare the general hierarchy of a multimedia presentation system with the multi-tier architecture proposed by us, and we can know how the tasks are divided and assigned to corresponding professionals to accomplish the whole teaching materials through working cooperatively. It is possible to have a suggestion to develop CAI software for educational department.

Keywords: **Multimedia Presentation System, CAI System, Multi-tier**

1 Introduction

Although there exists many arguments, object-oriented is still spread out in 1990's and it seems to be a possible survival direction in software crisis. Besides this, we can use component oriented to build a set of CAI systems via existing papers that can be divided into several areas, e.g. research of interface, learning methods of computer assisted instructions, application of virtual reality, networking exam, virtual classrooms (including distance instruction), individual researcher objects, and etc. For example, the processes of mental model research emphasize the use of information of objects, so researchers just make the analysis components of mental model, the key point of this study is the component of mental model, not the scenario of teaching and the interface of designation. Another example, fuzzy theory should be used in the research of learning analysis, the key point is to provide learning analysis for content of exam, and it can make the analysis component purely. From the two examples, we can find the generation in proper components analysis, so all we have to do is making the component of its own domain. Each researcher only concerns its own theme without being concerned with the entire system, then can reuse the resources and get the complete experimental environment. This thesis constructs the developing architecture of CAI through component oriented and logical dividing of multi-tier structure, and emphasizes that the discussion of developing architecture is the beginning of the series of research.

2 Multimedia presentation system

2.1 General Hierarchy of Multimedia Presentation System

On Internet, the way to play multimedia objects is hypermedia shown in the Fig.1. To display such a scene on homepages, we can divide the designation into two layers, frame layer and resource object layer. The resource object layer stores all the multimedia objects participated in playing, the frame layer records the objects that compose each frame, the schedule of playback, the arrangement of objects on screen, and the events that may change the playing flow of inter-frames.

A multimedia resource may be a picture, a text description, a video, or other materials that can be used in a multimedia computer. A topic is a resource carrier that presents the resource to the addressee. A frame is a composite object that represents related issues that a presenter wants to illustrate. A frame may contain push buttons, one or more topics to be presented, and a number of knowledge. A message with optional parameters can be passed between two frames (or back to the same frame) to trigger a multimedia presentation action.

In the two layers, we make some definitions by referring the various links defined in [7].
An inheritance* (successor or precedence) *link: is a property inheritance between two frames and is used in the process of knowledge collection of an activated frame before the logical inference of the frame proceeds.
A usage link: is a link that represents a message passed between two frames.
An aggregation link: indicates that a frame is using a resource.
A resource association link between two resources: indicates that the two resources are correlated.
A frame association link between two frames: indicates that the two frames are correlated.

2.2 Models of Presentation systems

In 1983, James F. Allen advocated in ACM• There exist thirteen temporal relationships between two intervals, namely, before, meets, overlaps, during, starts, finishes and the other six inverse relations as well as equal. The thirteen corresponding temporal operators constructed from the Allen's interval-based temporal logic are depicted in Fig. 2.

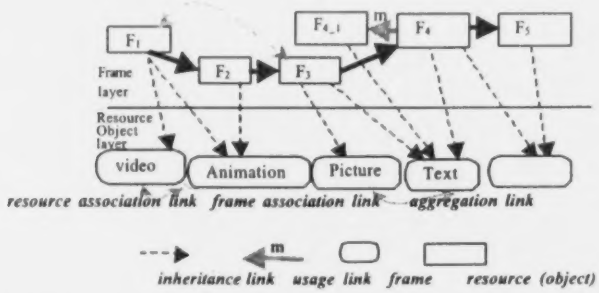

Fig.1 the way to play multimedia objects on Internet is hypermedia

Relation	Diagram	expressions	relation	Diagram	expressions
P before Q	P Q	P; ε(n);Q	P before Q	Q P	P‖ Q
P meets Q	P Q	P;Q	P meets Q	P Q	P‖ Q
P during Q	P Q	P‖ Q	P during Q	P Q	P‖ Q

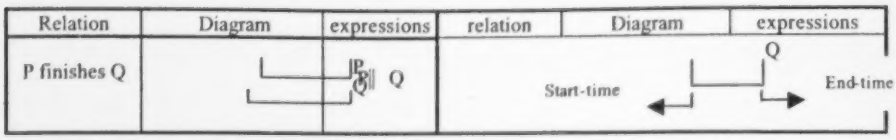

Fig. 2 Temporal Relationships (Allen 1983) and their corresponding temporal operators

2.3 Define the Playback of Multimedia Presentation

We define some notations used in our presentation system. The F_i denotes the frame in the frame layer. The O_i denotes the resource in resource layer. The $F_i.O_i$ denotes that the resource O_i is one component of the frame Fi. The m_i denotes a triggered message when users push a button, a hypertext or a hypermedia. The m_iF denotes that the frame F will be displayed after the message mi is triggered, and the m_eF denotes that the frame can be directly displayed not depend whether the message is triggered or not.

For example, a presentation displayed one frame by one frame can be described by the following expression $S = m_eF_1\ (m_iF_{21}+m_eF_{22})\ m_eF_3\ m_eF_4\ (m_iF_{51}+m_eF_{52})$. According to Fig.1, we know that the $F_i.O_i$ is an aggregation link, m_eF_1 is an inheritance link, and m_iF_1 is a usage link.

2.3.1 Define the Properties of scenario

A complete process of instruction is just like the scenario of a presentation, and can also be described by the expression $S = m_eF_1\ (m_iF_{21}+m_eF_{22})\ m_eF_3\ m_eF_4\ (m_iF_{51}+m_eF_{52})$.

2.3.2 Define the Properties of Objects

We denote a media object as O = (N, T, D, UM, OAL, PT), and describe the attributes of an object below:
O_i.N *(Name)*: is the identifier of the object.
O_i.T *(type)*: What multimedia device is used to carry out this resource (e.g. sound, video, text or picture).
O_i.D *(Duration)*: records the display time of the object.
O_i.UM *(Usage model)*: the situation about the usage of objects, such as the object is a background or a referent.
O_i.OAL *(object association link)*: describes the relationships between objects, and is specified like
O_i.FAL={O_1(*association Keyword description*), O_2 (*association Keyword description*) ,..}, we use association keywords to describe the related relationships between O_i and O_1, the same as O_i and O_2.
O_i.PT *(Player Type)*: describes the way to play the object.

2.3.3 Define the Properties of Frames

A frame F_i is denoted as F_i =(N, O, FAL, L, P, UM), and the meanings of its attributes are listed below:
F_i.N*(Name)*: assign a unique name to a frame F_i.
F_i.O*(resource objects)*: the set of all the resource objects participated in the frame F_i, $O = \{ O_i \mid O_i \in O \}$.O is the set of all objects stored in database.
F_i.FAL*(frame association link)*: $F_i.FAL = \{(C_i, F_k) \mid C_i \in \{\Diamond, \odot\}, F_k \in F\}$.The relationships between F_i and F_j are divided into inclusive and exclusive relationships; we denote them by $\odot$ and $\Diamond$ respectively. The $F_i \odot F_j$ represents the two frames are inclusive, that is, whenever the F_i is displayed, the F_j must be displayed also. The $F_i \Diamond F_j$ represents the two frames are exclusive, that is, whenever the F_i has been displayed, the F_j can't be displayed. F is the set of all frames.
F_i.L *(Layout)*: the spatial arrangement of the objects of F_i for the presentation. For example, the (X_{j1}, Y_{j1}) and (X_{j2}, Y_{j2}) are the position on the screen arranged for O_j, $F_i.L = \{O_1\ (X_{11},Y_{11})(X_{12},Y_{12}),\ O_2\ (X_{21},Y_{21})(X_{22},Y_{22}), ...\}$.
F_i.P *(Presentation)*: the duration of playback of all objects in the F_i. We use the 13 temporal relations proposed by Allen and use ε(n) to represent units of time. OP is the set of all operators used to describe the temporal relations between objects. P is a set composed of O_i OP O_j, $P=\{(O_i, op, O_j) \mid O_i, O_j \in O, op \in OP\}$, $OP = \{ ;, \|, \|, \|, \|, \|, \varepsilon(n)\}$,$F_i.P=\{\cup P_i \mid P_i \in P_j'\}$. For example, $F_i.P=\{(O_1 \| O_2),(O_1 \| O_3),(O_3 ; O_4),..\}$.
F_i.UM*(Usage model)*: describes usage of frames, e.g. the frame is designed for teaching or for taking exams. For example, expression $F_i.UM$ = exam means that the frame is an exam frame.

3Three-layer CAI architecture

3.1 Partition the CAI system into Components

The flow of instruction is from teaching course, taking examinations, speculating the advanced contents of instruction according to the result of examination, to achieve the goal of instruction. Generally, the teachers, educators or scholars take part in editing the CAI systems and the computer engineers are responsive for implementing the CAI systems, so they often spent lots of time on mutual communication. We analyze the CAI systems and partition the CAI systems into various components that are designed by various persons respectively, and these persons work together to achieve the whole function of the CAI systems. To partition the components clearly, we use the UML to describe the flow of CAI systems shown in the Fig.3, and we can know the following things:

- Step1 to step4 is for identifying the users.
- Step5 to step8 is for displaying the teaching of courses or questions of exams.
- Step9 to step11 is for analyzing after the exams are finished.
- Step12 to step14 is for designing the advanced courses after the fitting analysis is finished.
- Step15 is for exiting the CAI system.

In Fig.3, we can classify the partitioned components of CAI systems into four kinds listed below.

- The verification component for logging the usage of systems and maintaining the security of system. —is managed by system administrators or computer engineers.
- The course and exam component for instructing students in learning and taking exams. —is managed by teachers, educators or scholars.
- The fitting analysis component for the learning process of students. —is made by educators and scholars.
- The database component for storing the media objects and instruction materials. —is implemented by art designers or computer workers, and is managed by computer engineers.

3.2 Three-layer CAI architecture

From the CAI system described with UML shown in Fig.3, we can know that the course and exam component is the most important one and the other components are discussed in other area. In our system, we propose the Multi-layer CAI architecture to construct the CAI systems, and use the management of components to distribute the resources over the servers on Internet to achieve the goal of resource sharing.

We present a 3-layer CAI architecture model that expresses different points of view and is fully flexible and component oriented [2,3]. Based on the efficiency of systems, the model is partitioned into 3 layers--resource layer, presentation layer and evaluation layer. It raises the productivity of system development and improvement process, also promotes the individual skills and development of distributed computing environment.

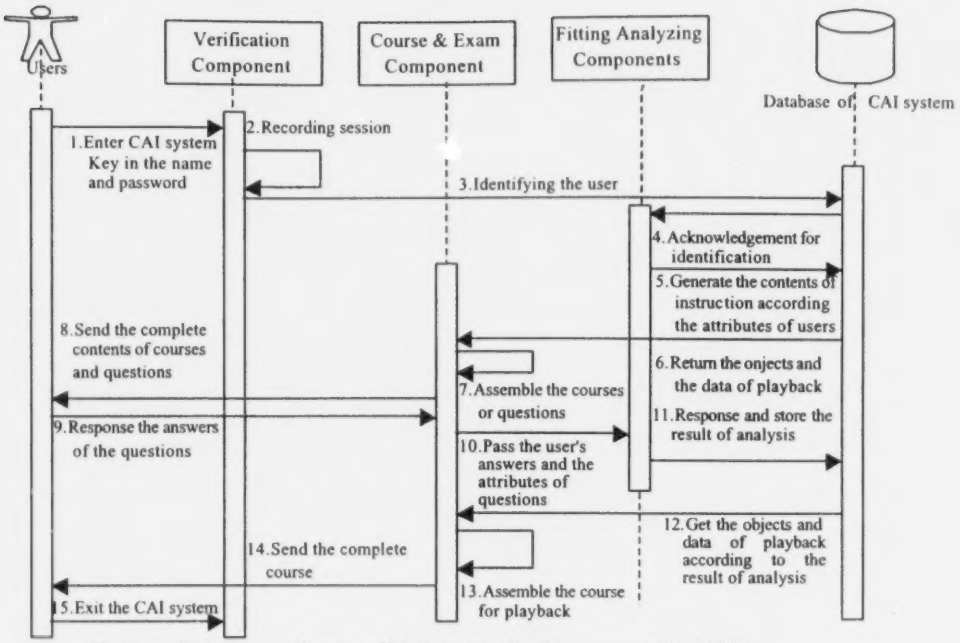
Users
Verification Component
Course & Exam Component
Fitting Analyzing Components
Database of CAI system
1.Enter CAI system Key in the name and password
2.Recording session
3.Identifying the user
4.Acknowledgement for identification
5.Generate the contents of instruction according the attributes of users
6.Return the onjects and the data of playback
7.Assemble the courses or questions
8.Send the complete contents of courses and questions
9.Response the answers of the questions
10.Pass the user's answers and the attributes of questions
11.Response and store the result of analysis
12.Get the objects and data of playback according to the result of analysis
13.Assemble the course for playback
14.Send the complete course
15.Exit the CAI system

Fig.3 use the Sequence diagram of UML to describe the process of CAI [8][9]

3.3 Relationship between Three-layer CAI architecture and hypermedia

From the Table 1 and the frame and resource objects defined in our multimedia presentation system, we can analyze that to what layer the settings of various objects belong listed in Table 2[2][4]. In the components of scenario, we define the miFi that describes which frame should be displayed after the message is triggered, i.e. we can use the expressions to define the schedule of playback of the frames about designing exams and teaching. The components of plot or story just describe the flow of teaching courses defined by users.

From Table 3, we can design and implement the system on Internet more easily to let teachers or other education experts design their teaching materials or questions of exams conveniently and systematically.

4 Conclusion

Different researchers can benefit from this architecture by studying their own knowledge domain independently. Shortening the time spent on completely developing the whole system is to promote the successful rate of resolving the kernel problems. Researchers can't benefit from studying their own domain only; it's necessary for them to know our open architecture that can easily expand one system into various domains.

Users can acquire an easy-used and reusable system from defining components of multimedia and instructive units of CAI. Our architecture lets teachers have the suitable flexibility and lets various experts and scholars participate in the installation of CAI system. The educational authorities can take our architecture as a referenced architecture for developing the multimedia education. Our system is shown in Fig. 4. The prototype of our system has been completely implemented and published in some various conferences or journals. [1] [5] [9] [10]

Table 1. Three-layer CAI architecture [2][4]

Layer	Researcher	Participants
Resource	Researcher of Interface	Designer of animation , graphic, sound
Presentation	Researcher of learning theory	Teacher, Instructor
Evaluation	Researcher of evaluation	Manager, researcher of educational policy

Table 2. Explanation of part of components [2][4]

First layer (Evaluation layer)	
Components of fitting analysis	This component is made according to some theorem. After analyzing the data acquired from the process that the students take exams and learn, there are some various frames generated.
Components of evaluation and analysis	This component is made according to learning evaluation and learning retrieval of theorist or researchers.
Second layer (Presentation layer)	
Components of scenario	This component is made according to the researchers of learning theory or teaching materials.
Components of structure	This component is made according to learning environment.
Third layer (Resource layer)	
Components of exam	This part must include the parameter or properties which is used broadly
Components of background	Background is concerned to the interest and attention of learner.
Components of referents	To help users of different levels from different method and presentation
Components of multimedia	The components make the CAI lively which may be somebody of cartoon

Table 3. Explanations of part of components

Explanation of part of components		Set the values of necessary item needed
First layer (Evaluation layer)	Components of fitting analysis	
	Components of evaluation and analysis	• F_i.O • F_i.Layout and F_i.UM= exam • F.Presentation and F_i.UM= exam
Second layer (Presentation layer)	Components of scenario	• S
	Components of structure	• F_i.Layout and F_i.UM=learn • F.Presentation and F_i.UM=learn
Third layer (Resource layer)	Components of exam	• O_i.UM = exam
	Components of background	• O_i.UM =Background.
	Components of referents	• O_i.UM = Referents

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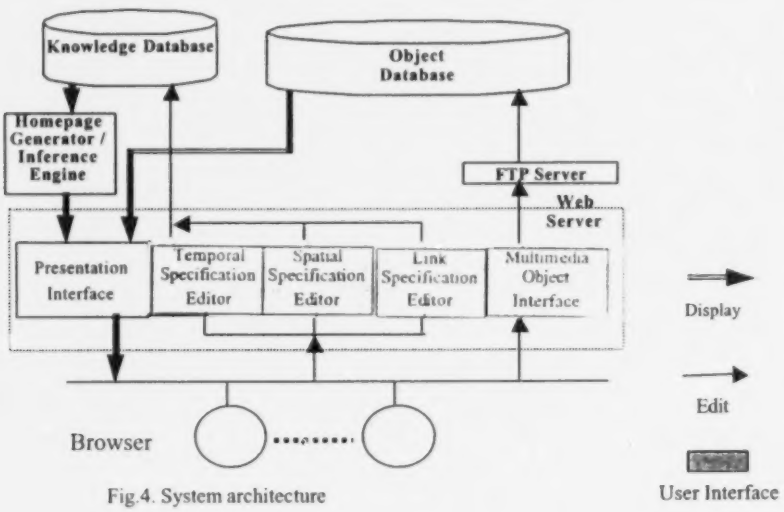

Fig.4. System architecture

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CAI System Generator on Web -- using Automatic Trace Recording

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By the prosperity of computer media, many companies treat electric media as their developmental base and use these electric media in more effective way. It goes without saying that the domain of teaching has developed on the Internet and many CAI systems have been already used in the teaching. The goal of our research is to create CAI systems by automatically recording the trace of editing. So in the thesis, we define the actions of users through image, audio, schedule, point and the module of event, and present the generated CAI systems dynamically on web.

Keywords: **CAI System Generator, Multimedia, Web**

1 The goal

Currently, many teachers and students use CAI systems as their teaching tools, and most teaching materials are designed by both teachers and system engineers. But teachers are generally in the passive position, and if they want to make teaching materials according to their own ideals, they have to learn how to use HTML to design homepages. Usually, students may not understand the meanings of teaching materials very well through the static homepages written in HTML. So we propose and implement an auto-recorded multimedia presentation system to let authors construct dynamic homepages of CAI systems directly through browser on web from automatically recording the trace of their editing.

2 Structure of system

We show the structure of our system in Fig. 1. In the auto-recorded system, we can catch the screen of process of users' operations, or insert sound or image information to the process. Then, these multimedia resources and related information are stored in Information Database and Media Database. The information of presentation schedule is recorded in information database. In the media database, contents of multimedia objects are recorded. In Fig.2, we can see the interactions among Image, Sound, Timer, pointer and Event. Image Module is to make necessary pick-ups for required images, decide what images are picked up in the Event Module Database and store their transition and filename in the forms. Sound Module is used to record sound, thereafter the sounds can be played at proper time by temporal scheduling. Pointer Module is to record the location of mouse pointer. When the transition has something wrong, we can make an adjustment in the coordination. In Timer Module, the time sequences are recorded in the form of Timer Pointer. The schedule designed through directly recording or specified by users is stored in the event database, and the generated multimedia objects will be presented according to the schedule built on the Timer Pointer. Event Module will react to all the other modules. It can decide what modules are going to work, and react to them. When users need to present teaching materials, the Java & HTML Generator will generate and send java code and HTML code to users' browser, then users can see the dynamic homepages. In Fig. 3, we can see a dynamically presented Web CAI system that is produced by recording and modified through the authors' edition and arrangement.

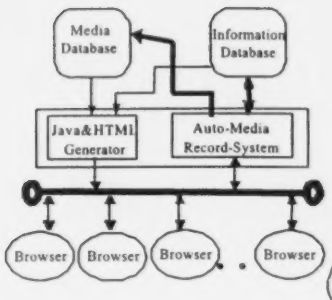

Fig.1 Structure of System

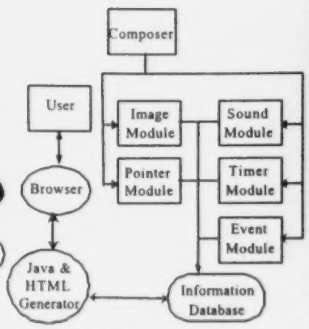

Fig.2 Modules of System

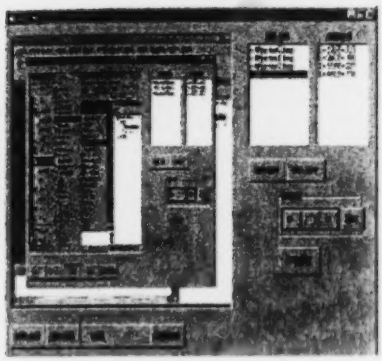

Fig.3 The interface of Auto-Recorded System.

3 Conclusion

We still continuously work on the pack technique of the multimedia file because the transmittance of image and audio are limited by the bandwidth of the Internet. However, teaching through Internet is an inevitable trend in the future, so how to make the best efforts between editing the teaching materials and let the learners learn as efficiently as possible are our goals.

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CoCoAJ: Supporting Online Correction of Hypermedia Documents for CALL

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This paper describes an online markup-based composition learning environment system called **CoCoAJ** (Communicative Collection Assisting System for Java). It allows students and teachers to exchange marked-up documents via Internet, and its environment is very similar to a real world one in which people use pen and paper. In order to record and exchange corrected compositions with marks and comments, this paper proposes XCCML (eXtensible Communicative Correction Mark-up Language), that is based on XML (eXtensible Mark-up Language). XCCML facilitates teachers to analyze and reuse the marked-up documents for the instruction.

Keywords: **Computer assisted language learning, Collaborative writing, XML, Online document correction, Hypermedia.**

1 Introduction

Recently, teacher-centered instructional approaches in traditional writing classrooms are replaced with more active and learner-centered learning approaches with collaborative writing tools[2]. These tools can (1) change the way students and teachers interact; (2) enhance collaborative learning opportunities; (3) facilitate class discussion; and (4) move writing from solitary to more active and social learning. Writing compositions includes various sub-processes such as planning, transcribing, and revising, which do not need to occur in any fixed order [19]. In particular, the review process assisted with computer-based writing tools, has recently received much interest (see as examples [4, 9]).

Many researchers developed online markup systems employing some markup models. However, it is very difficult to analyze and reuse the marked documents that are collected through the writing classroom because the documents do not have a common structure. Therefore, it is necessary to define the generalized format for encoding and exchanging the marked-up documents in order that online markup systems are used easily and widely.

CoCoA (Communicative Correction Assistant system) has been developed for supporting foreigners and teachers to exchange marked-up documents by e-mail [14]. Its environment is very similar to a real one in which people use paper and pen. CoCoA allows teachers not only to correct the compositions sent from foreigners by E-mail, but also foreigners to see where and why the teacher had corrected them. CoCoA improves the opportunities that foreigners have for writing Japanese compositions and for receiving instructions from teachers. **CCML** (Communicative Correction Mark-up Language) [15] has also been proposed for the representation of marked-up documents, which is based on **SGML** (Standard Generalized Mark-up Language) [8]. With CCML, teachers and students can exchange marked-up documents via e-mail [16, 17]. In the experimental use of CoCoA, most of users commented that CoCoA was easy for them to understand the mistakes in documents because of the use of marks, and that the optional view of the original, marked or revised text was very useful. However, CoCoA cannot show users a hypermedia document including figures, tables, movies and links because it deals with only text.

This paper tackles how to correct hypermedia documents by the extension of CoCoA. This paper proposes **CoCoAJ** (CoCoA for Java) to do so. Also this paper describes **XCCML** (eXtensible CCML) for correcting

hypermedia documents, that are based on XML (eXtensible Markup Language). XCCML is combined CCML with HTML (Hyper Text Markup Language) that can represent hypermedia documents including pictures, movies, audios and so on.

We have been investigating technological support for Japanese language learning among overseas students. For example, CAI systems called Kanji Laboratory [7], JUGAME [23], GRACILE[23] and JULLIET[1] were developed to support Japanese language learning. However, an on-line mark-up supporting system for Japanese language learning has not yet been proposed. Usually, in a Japanese writing classroom, teachers have to individually review learners' documents using pen and paper[18]. It takes a lot of time for teachers to do this. Therefore, we have implemented CoCoA for writing Japanese composition.

2 Online markup models

There are some editing systems that support teachers to review and correct the students' drafts with online mark-up. Farkas & Poltrock [5] classified the mark-up models as followings:

(1) *Silent editing model*: This is the simplest model and it requires no special techniques. However, it is very difficult for the author to check the editor's work. This model is destructive because the editor cannot readily recover the original words once he/she has changed it.

(2) *Comment model*: This model employs pop-up notes, temporary footnotes, hidden text, and special symbols placed within the text. This model can work for special groups and ad-hoc situations. A system called XyWrite[10] was proposed with this model.

(3) *Edit trace model*: In this model, the editor works in the manner of an author, deleting, adding, and moving text as usual. The computer can compare the editor's new version with the original text, and allows the author to view the draft that contains the editor's changes. This model is apt to encourage heavier editing and less regard for the author's original text. Microsoft Word accepts this model.

(4) *Traditional mark-up model*: This adapts the traditional paper mark-up model to the computer screen. The symbols are both familiar and intuitive for editors and authors; for example, deletion, insertion, and move. For instance, Red Pencil allows the editor to apply a complete set of traditional editing symbols directly to a document. The editor uses "digital ink" to mark a traditional editing symbol along with the words. Moreover, MATE[6] allows the editors to use both digital ink and voice command toward pen and voice computing. In this model, authors and editors can interpret the editor's markings much more readily than in the edit trace model.

There are many systems that employ traditional mark-up which allows multiple users to mark-up an electronic document as if they were marking up a printed copy of the document. However, such systems do not globally come into practical and wide use in composition writing classes because of their special format. Moreover, it is very difficult to analyze and reuse the marked documents because the marked documents are unstructured. Therefore, the system should provide a generalized and structured format for encoding and interchanging marked-up documents via the Internet.

3 XCCML

Based on the experimental results, we propose XCCML for exchanging marked-up documents. XCCML is an application of XML, and it supplies a formal notation for the definition of generalized mark-up languages. XML is a device- and system-independent method of representing texts in electronic form. That is to say, XML is a set of mark-up conventions used together for encoding texts. A mark-up language must specify what mark-up is allowed, what mark-up is required, how mark-up is to be distinguished from text and what the mark-up means.

3.1 Features of XCCML

The main characteristics of XCCML are:

(1) Based on the experiment, XCCML presents six marks and annotation XCCML tags.

(2) The marks have three degrees of importance levels against respective corrections.

(3) The original text is generated through removing all the XCCML tags.

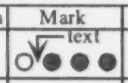
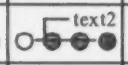
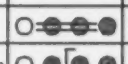
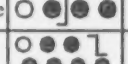
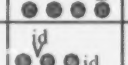
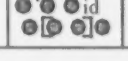
(4) The revised text is derived from the XCCML document.

(5) Because XCCML documents are text-formatted, it is easy to send them by e-mail.
(6) CCML documents easily make up full-text databases.
Needless to say, XCCML inherits its features from XML.

3.2 XCCML structure

As shown in table 1, XCCML documents consist of three parts: header, body and close. "Header" represents additional information about the document. For instance, "next" tag denotes the next version of the document. The marks for review are shown in the "Body" as XCCML tags. "Close" shows the editor's comments. In one sentence, "insert," "replace" and "delete" marks were used, while "join," "separate" and "move" marks were used over two sentences. The part between the start tag and the end tag denotes the learner's mistakes. The "string" attribute represents the revised part of the document.

Table 1: Marks and XCCML tags.

Correction	Mark	Tag
1. Insert		<Insert string="text"/>
2. Replace		<Replace string="text2"> text </Replace>
3. Delete		<Delete> text </Delete>
4. Separate		<Separate/>
5. Join		<Join/>
6. Move		<Movefrom refid="id"/> <Moveto id="id"> text </Moveto>

(1) Root tags

Tag name	Explanation	Attribute	Attribute's contents	End tag
XCCML	Beginning of XCCML tag	Version	Version number	</XCCML>
Head	Header information	None		</Head>
Body	Corrected document	None		</Body>
Close	Overall comments	None		</Close>

(2) Tags in header section

Tag name	Explanation	Attribute	Attribute's contents	End tag
Title	Title of the document	String	Title name	None
Editor	People who corrected the document	Name	Name of the editor	None
		Email	Email address	
Author	People who write the original document	Name	Name of the author	None
		Email	Email address	

(3) Tags in body section

Tag name	Explanation	Attribute	Attribute's contents	End tag
Insert	Insert words	String	Inserted words	</Insert>
		Level	Level of importance	
		Comment	Comment for the correction	
Replace	Change words	String	Corrected words	</Replace>
		Level	Level of importance	
		Comment	Comment for the correction	
Delete	Delete words	Level	Level of importance	None
		Comment	Comment for the correction	
Separate	Separate a paragraph	Level	Level of importance	None

		Comment	Comment for the correction	
Join	Join paragraphs	Level	Level of importance	None
		Comment	Comment for the correction	
Moveto	Moved position from the original spot	Fromid	ID	None
		Comment	Comment for the correction	
Movefrom	Original position of the words	Toid	ID	</Movefrom>
		Level	Level of importance	
Annotate	Comment for the correction	String	Annotation contents	None
		Level	Level of importance	

(4) Tags in close section

Tag name	Explanation	Attribute	Attribute's contents	End tag
Comment	Overall comment	None	None	Necessary

3.3 Level of marks

We found that the marks do not have the same level of importance. We identify corrections on the following levels:

(1) Weak correction: The learner does not need to revise the document.
(2) Normal correction: The learner should correct the document.
(3) Strong correction: The learner must correct the document.

The strong corrections denote the important part of marks to be revised in the document. Using the importance level that the teacher had entered, the system provides the learner with the marks he/she wants to see. Therefore, the learner can avoid information overload from the reviewed documents. Every tag in table 1 has an attribute "level" that a teacher gives a number from one to three. Its default is two as normal correction.

3.4 Level of annotations

It is very important for a teacher to annotate the marked text for instruction in composition. For example, PREP Editor [12] is a word processor that allows writers and reviewers to create electronic margins, or columns, in which they can write and communicate through their annotations. We identify the following different kinds of annotations:

(1) Explanation: This is used for explaining the reason of a correction.
(2) Question: This is used for asking the learner a question; e.g., what do you want to write?
(3) Comment: This shows the educational view of the teacher with respect to the document.

4 CoCoAJ

CoCoAJ consists of CoCoAJ-Editor and CoCoAJ-Viewer. A teacher corrects the document of overseas students with CoCoAJ-Editor and the system saves the marked document in XCCML format. CoCoAJ-Viewer interprets the XCCML document, and shows the learner the marked document.

4.1 Learning processes using CoCoAJ

By using CoCoAJ, a learner receives instruction about a Japanese composition from a teacher with the following processes:

(1) The learner writes an original text with his/her familiar editor.
(2) The learner sends the document to his/her teacher with his/her own e-mail tool.
(3) CoCoAJ-Editor makes the document double-spaced. The teacher corrects the document with online marks and annotations. Then, the system allows the teacher to set the importance level to the marks in the document.
(4) After CoCoAJ-Editor saves the marked text as a XCCML document, the teacher sends it to the learner by e-mail.

(5) CoCoAJ-Viewer provides the learner with the marked text after interpreting the XCCML document. Then, the system allows the learner to select the importance level to see the important part of the marked text.
(6) CoCoAJ-Viewer automatically generates both the original text and the revised one from the XCCML document. After editing the revised text, the learner can send it again to the teacher and continue refining the text.
(7) CoCoAJ maintains the version of the document, if the learner wants to revise the same document.

4.2 System configuration

Figure 1 depicts the learning environment of CoCoAJ.

(1) XCCML parser: This module analyzes XCCML documents using the XCCML parser after reading them through the file management module. Then, it provides the results of correction according to the level of importance of marks.
(2) Correction module: This module inserts XCCML tags into the learner's document, according to the revision of the teacher. After saving the marked text, the teacher sends it by e-mail to the learner.
(3) Original text display module: This module generates the original text from the XCCML document by removing all the XCCML tags.
(4) Revised text display module: This module generates the revised text by applying XCCML tags.
(5) File management module: This module manages the versions of the documents. When the learner sends the teacher the revised document, the system creates a new XCCML document, inserts the "next" tag into the old XCCML document, and also enters the "previous" tag into the new XCCML document.

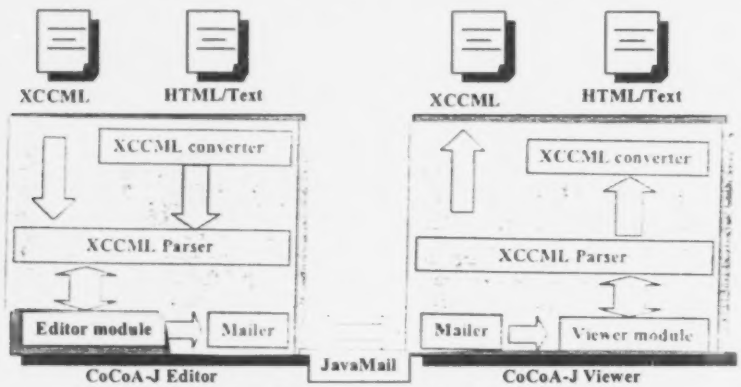


Figure 1: System configuration of CoCoAJ.

4.3 User interface

Figure 2 shows the screen snapshot of CoCoAJ-Editor. First, the learner writes a Japanese composition with a word processor and saves the document as HTML format. After that, the learner sends the document to the teacher by e-mail. By selecting a mark from the mark palette shown in the upper window, the teacher can revise the document. Moreover, the teacher can annotate the document using the annotation palette, and he/she can classify the marks according to the level of importance. The user can see the correcting document at the left side in the window and "*" means the user inserted the comment. The user can see the comments for the correction at the right side in the window. In this figure, the teacher substitutes "allow" with "allows" and gives a comment "*2". Also the teacher can see the original document and revised one by selecting window tag. After saving the marked document as a XCCML (see appendix A), the teacher can send it to the student by e-mail. Using CoCoAJ-Viewer, the learner obtains the same marked text that the teacher revised. By selecting the level of importance, CoCoAJ-Viewer provides only the marks over the level. The learner can reply to the teacher's comments and collaboratively write a composition with the teacher.

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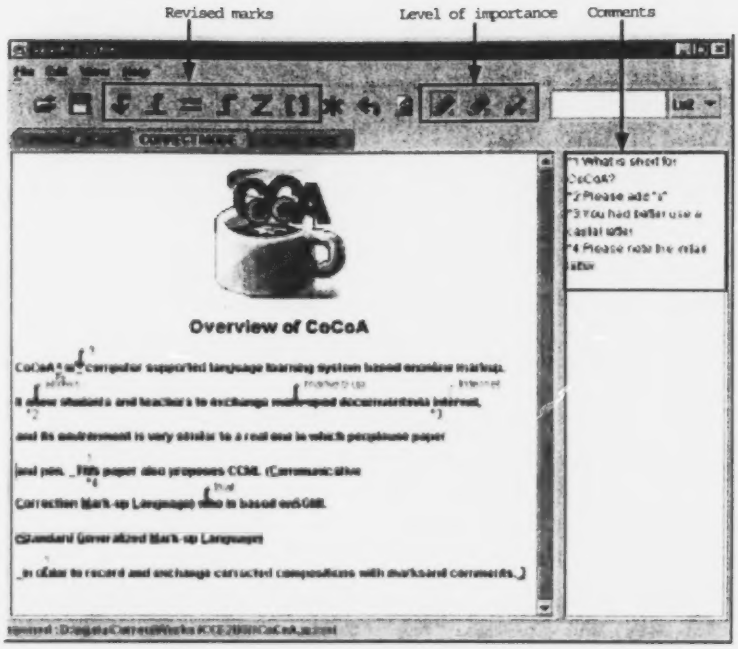

Figure 2: Screen snapshots of CoCoAJ-Editor.

5 Conclusions

This paper proposed a computer mediated language-learning system called CoCoAJ and XCCML for exchanging electronic marked-up documents. Now we are trying to propose XCCML to W3C (World Wide Web Consortium), and to show an XCCML document into Web browsers. After that, CoCoAJ will be able to be used for learning any language in an open-ended writing classroom. In our future research, we will investigate how to classify students' writing errors in their drafts, and how to assist a review process with AI technologies.

Acknowledgment

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Appendix A: **XCCML document in figure 4.**

```
<?xml version="1.0" encoding="Shift_JIS"?>
<!DOCTYPE XCCML SYSTEM "XCCML.dtd">
<XCCML>
<HEAD>
<Title string="Overview of CoCoA"/>
<Editor name="Hiroaki Ogata" email="ogata@is.tokushima-u.ac.jp"/>
<Author name="Yoshiaki Hada" email="hada@is.tokushima-u.ac.jp"/>
</HEAD>
<BODY>
<CENTER><IMG width="128" height="128"
src="image001.gif"/></CENTER><CENTER><H2>Overview of CoCoA</H2></CENTER> <H4>
CoCoA <Annotate level="3" comment="What is short for CoCoA?"/> is<Insert string="a" level="3"/>
computer supported language learning system based ononline markup.<BR/>
 It<Replace string="allows" level="3" comment="Please add &#34;s&#34;."> allow </Replace> students
and teachers to exchange<Replace string="marked-up" level="3"> mark-uped</Replace> document via
<Replace string="Internet" level="1" comment="You had better use a captal letter.">
internet</Replace>,<BR/> and its environment is very similar to a real one in which people use paper<BR/>
and pen. <MoveTo fromid="1" level="2" comment="Please note the initail letter."/>This paper also
proposes CCML (<U>C</U>ommunicative<BR/> <U>C</U>orrection <U>M</U>ark-up
<U>L</U>angua<Replace string="that" level="3">ge)</Replace> who is based on SGML<BR/>
 (<U>S</U>tandard <U>G</U>eneralized <U>M</U>ark-up <U>L</U>anguage)<BR/>
<MoveFrom toid="1" level="2">in order to record and exchange corrected compositions with marks and
comments.</MoveFrom></H4></BODY>
<CLOSE>
<Comment/></CLOSE>
</XCCML>
```

Design and Implement CAI Programs for Adult Literacy Learners

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This paper discusses adult learners' learning characteristics and how to integrate their characteristics with proper learning theories to make the CAI design more appropriate for adult learners. Three important issues concerning CAI design features are discussed: (1) learner control, (2) feedback and reinforcement, and (3) cooperative learning. Suggestions for CAI software designers about CAI design features and for adult literacy educators in implementing CAI programs are provided at the end of the paper.

Keywords: **Computer-Assisted Instruction (CAI), Adult Literacy Education**

1 Introduction

The computer has been attracting adult literacy educators' attention because it provides solutions to problems which have been plaguing adult education. For instance, it allows self-directed learning. Privacy is also possible. In addition, it provides flexible scheduling for adult learners. However, several limitations exist. One of the biggest problems with computer-assisted instruction to adult literacy education is the lack of CAI designed to meet the specific needs of adult learners. This paper discusses learning characteristics of adult learners, issues concerning CAI design features for adult literacy learners and provides suggestions for computerized adult literacy education.

2 Adult Learners' Learning Characteristics

Summarizing many adult educators' findings about adult learners' development and learning, the author generated a list of learning characteristics of adult learners. (1) Self-motivated: adults have a self-concept of being responsible for their own decisions and for their own lives. They want to be involved in making mutual decision about the learning process. (2) Experienced: adult learners want the learning experience to relate to their real-world experiences. (3) Practice-oriented: adults learn better by really doing something rather than hearing theory only. (4) Pragmatical: adults need to know exactly what the learning objectives are and how they will apply them in their daily lives. (5) Self-evaluated: adults like to know how they are progressing, but they tend to shy away from tests because of the fear of being humiliated if they do not do well. (6) Varied learning style: adults have adopted a particular learning style and it is not easy to change it. Thus adults want a variety of learning techniques utilized.

3 Issues Concerning CAI Design Features for Adult Literacy Learners

Learner control is particularly important for adult learners for three reasons: (1) adults need to control their learning, (2) they may need more time to make decisions about the learning topics and procedures, and (3) their learning may be ineffective in a learning situation with speed constraints [7].

Researchers have suggested effective instructional materials for adult learners should include feedback and reinforcement [2, 7, 9]. Chen [4] also asserted that positive and explanatory feedback had significant positive effects for adult learners' achievement and attitude toward instruction.

The rich resources of each adult's unique experiences and differing contexts should be focused on and integrated into the learning environment [11]. Steeples [11] concluded that, "Learner collaboration not only emphasize a positive, constructive approach to learning but it also allows the knowledge and skills of the participants to be shared with their peers and with others who have similar interests and concerns" (p. 452).

4 Suggestions

1. Design CAI for knowledge application. CAI for adult literacy education is still limited to specific learning subjects, such as language and mathematics. However the final goal is for the indivjdual to be able to apply these skills to meet the needs for dealing with daily life. CAI designers should expand adult literacy learning subjects from the basic knowledge level to the advanced application level.

2. Develop daily-life-related simulation programs. To expand learning subjects from the basic knowledge level to advanced application level, a more complex learning environment is needed. A daily-life-related program could simulate real world environment, such as food markets, banks or hospitals, and allow learners to experience and solve problems happening in daily life. A tutorial section might also be integrated with the simulation program to provide instruction whenever needed.

3. Apply advanced computer technology. A simulated real environment can be displayed in a video segment or a Quick Time movie. The learner uses the computer to control the video to playback and retrieve information needed to solve the problems presented in the computer. A daily-life-related simulation program delivered by a multimedia system would motivate adult learners and improve their achievement.

4. Consider adult learners' vocabulary ability. Instructional developers must understand adult learners' vocabulary ability and develop easy-to-read text for adult learners improve their literacy ability in a progressive way. An option for audio to explain program usage methods and important information in plain daily-life language should be provided.

5. Develop CAI for both cooperative and individualized learning environment. When designing CAI software, neither individualistic nor cooperative learning should be viewed as the ultimate delivery system for adult literacy education. CAI programs that can be implemented in both individualized and cooperative learning environments would be more practical and effective for adult literacy learning.

6. Integrate varied software interactivity. The interactivity level of CAI should be carefully determined and designed after considering learners' characteristics, subject matter, and learning outcomes. When drill-and-practice learning mode is needed to help learners master some specific skills, semi-interactive CAI software might be a good design approach. If the learning outcomes are advanced knowledge application, CAI which provides high level of interactivity would be needed.

7. Apply multiple media with adult literacy teaching activities. When a learning environment provides varied learning media to facilitate students' learning, it is called a multimedia learning environment. If a computer-controlled multimedia is not available, adult literacy educators are encouraged to create a human-controlled multimedia learning environment for learners.

8. Let learners decide to learn individually or cooperatively. CAI designers are suggested to develop CAI which can be implemented in both individualized and cooperative environments. Adult literacy educators are also encouraged to let learners decide their CAI learning strategies. Learners can choose to learn individually, in pairs, or in groups of more than two.

9. Help learners obtain positive attitudes toward using computers. Teachers or trainers should avoid jargon when explaining how to operate a computer and access CAI program. Adult education organizations should offer a short pre-training program to help learners orient themselves to a computerized learning environment. Finally, adult learner grouping should pair learners who have never used computers before with learners who have had some computer experience.

10. Provide flexible learning schedule and learning location. CAI adult literacy educators should provide adult learners, who usually have many different obligations, with flexible learning schedule and choices of learning locations when implementing CAI programs for adult learners. This special feature of CAI—always providing organized and uniform instruction—should be fully used and enjoyed by adult learners.

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Designing for Interactivity

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In education, 'interactivity' is the catalyst that has transformed the traditional classroom setting into an active media environment. Yet the standards for interactivity within education are by no means clear. Educators and multimedia designers are confronted with many questions concerning the effectiveness of interactive courseware as a learning tool. In this paper, the authors draw on their experience of producing the interactive courseware package *Virtual Language University*, an interactive multimedia package for language learning that has over 3,500 interactive tasks. Specific topics in the paper include screen design, navigation, effective task writing, choices in the type of user feedback, scoring and testing. Attention is given to decision-making procedures that deepen understanding, promote interactivity and encourage self-direction.

Keywords: **interactivity, multimedia, courseware design**

1 Introduction

In education, interactivity has transformed the traditional classroom setting into an active media environment. As Laurel indicates, interactivity is a necessary component for learning to take place. Learners only learn how to learn when they are actively and continually involved in the learning process [13]. Yet the standards for interactivity within education today are by no means clear. Educators and multimedia designers are confronted with questions concerning the effectiveness of interactive courseware as a learning tool, such as: how multimedia can be successfully integrated into the classroom, what level of interaction should be included, and which programs are most suitable. As this new area of learning evolves, those involved in interactive learning are discovering that developing material according to a multimedia interface is simply not enough [25]; [26]; [5]; [3]. Courseware designers are being challenged like never before to produce material that deepens understanding, promotes interactivity and encourages self-direction.

In this paper, the authors draw on their experience of producing an interactive courseware package to discuss the primary areas involved in designing a multimedia program in a Higher Education institution. A review of multimedia production discourse will be used to connect the discussion to broader issues within educational technology and interactive learning. Attention will be given to the decision-making procedures that add to an enhanced level of interactivity within computer-assisted learning.

2 Development Environment

2.1 Virtual Language University (VLU)

Virtual Language University (VLU) is an interactive learning program developed at the City University of Hong Kong. The courseware consists of four CD-ROMs and aims to provide a self-directed learning tool for students and academic staff interested in improving their English skills. The two-year long project was

funded by the Teaching Development Grant of the University Grants Committee. The development team that was responsible for creating the program was an eclectic international mix, consisting of a project manager, three computer programmers, a graphic artist, two scriptwriters and several student helpers. This team worked closely during every stage of the production, including the conceptual phase of brain-storming and scriptwriting, and the production phase of computer programming, video recording, and graphic design. The program was completed after an extensive review and piloting process that took several months.

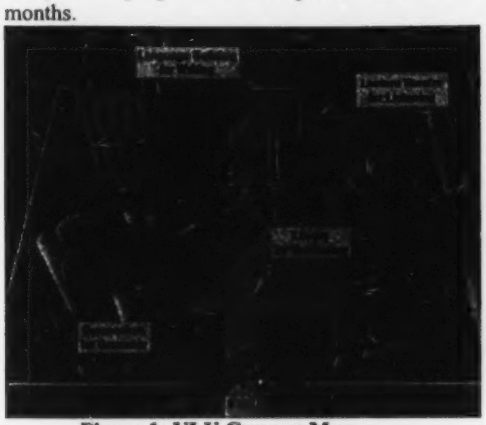

Figure 1: VLU Campus Map

Figure 2: VLU Lobby

Upon entering VLU, users are introduced to four units: Listening, Writing, Vocabulary and Grammar, metaphorically represented as four separate buildings in a virtual university campus (See Figure 1). The animated host, a friendly Dr. Einstein, provides first time users with a tour of the campus and explains how the program works. Once the users have selected a building (or unit) to work in, they are given a test and provided with feedback on weaknesses before being directed to the appropriate level: 1, 2, or 3, with 1 being the easiest (See Figure 2). For example, the Listening Unit consists of five multimedia lectures from University professors, which include video, graphics, sound and about 40 tasks per lecture. Users can control the forward, back and replay buttons of the lecture, and in this way monitor their own pace and approach in a "learner controlled" environment [5]. Within the Writing Unit, a video tutorial by an actual English teacher guides the students through complex writing structures, pausing for interactive tasks along the way. The other sections, Grammar and Vocabulary, provide ample practice for users to improve their proficiency in grammar usage and to expand their vocabulary. In total, there are over 3,500 interactive tasks in the program, all of which are programmed to give immediate or delayed feedback and a percentage score after each task. Users can also access their last two scores, as this information is automatically stored in the computer.

2.2 Project Development

Developing a multimedia product calls for a collaborative effort from various team members drawing from different backgrounds. The team usually includes a project manager (who is often the instructional designer), a subject-matter expert, scriptwriters, computer programmers, graphic artists, a videographer, an audiographer and administrative support [2]; [15]. The success of an interactive learning product depends very much on the ability of the team to work together; "As multimedia development demands the cooperation of many highly skilled and talented individuals, division of responsibilities, smooth communication, and strong commitment to the objectives of the project are essential to make a project successful" [15]. Depending on the size of the team, one person may take on several roles throughout the course of a project, or roles may overlap - as was the case for the production of VLU.

The project manager addresses the conceptualization stage [[9] and plans the instructional design. This involves a critical look at the educational needs, the interface design and a proposal for the delivery

content. The project manager will identify the instructional goal of the program, which should define, in general, what the program intends to achieve [2]. At the same time, s/he will determine the learning characteristics important to the design, such as the level of instruction, language, age and culture of the end users. The project manager is also responsible for outlining the schedule for the project and may facilitate a liaison with external specialists. S/he coordinates the efforts of the team, encourages positive interpersonal communications, and ensures that team members stay on track and complete their part by specified deadlines [2]; [15].

The scriptwriter works with the project manager to develop the content and design of the final product. S/he is responsible for selecting appropriate media, writing tasks, creating storyboards as well as developing ideas for graphics. Together, the project manager and scriptwriter construct the skeleton for the project, which is then brought to life by the programmers and graphic artists. The early phase is probably the most important stage of the production - and, if done properly, can save hours of time in unnecessary programming and tedious revisions.

Once the programmers and graphic artists have the scripts in hand, they can proceed with the production phase. They may use a number of authoring programs, systems or languages to implement the suggestions of the scriptwriter and project manager [2]. The graphic artist designs the program's graphics and animation, working closely with the scriptwriter to ensure everyone is thinking in the same direction. The videographer collects and digitizes video and photo images and the audiographer records the necessary sound elements. In the case of VLU, university professors were videotaped professionally. Academic lectures were given on different topics, such as "Exploring the Internet", "Organizational Behavior" or the "Poetry of Cavafy". The scripts for the lectures were first written by the professors and then transformed into an interactive format by the scriptwriter and project manager. The professors also acted as the subject-experts of the team, providing specialized feedback during the piloting of the program.

2.3 Scriptwriting

The key to good interactive multi-media packages is the nature and level of interaction between the users and the application. The level of interactivity is directly related to the successful creation of appropriately placed tasks that range in nature and content. During the scriptwriting stage, decisions concerning the number and type of tasks, the style of feedback, the sequence of questions, the different levels of tasks and the type of scoring are made. The decisions should first be organized into an outline form to give a broader perspective and to ensure there is an appropriate distribution among all the categories. It is also important for scriptwriters to maintain consistency throughout the scripts with the use of identical terminology, predictable sequences and the same command language.

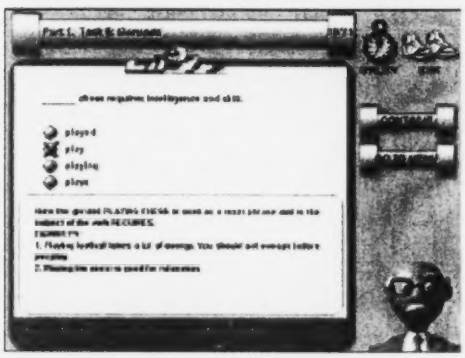

Figure 3: Grammar

Figure 4: Writing

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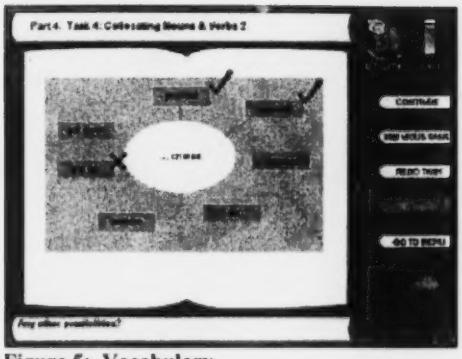

Figure 5: Vocabulary

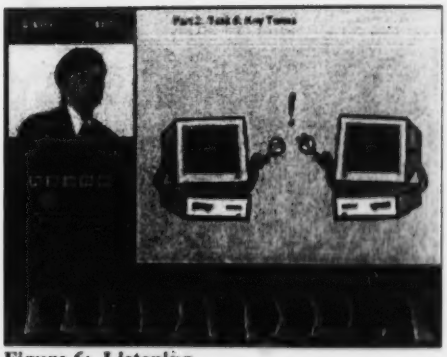

Figure 6: Listening

In VLU, tasks were written according to the instructional aim of each of the four units (See Figures 3-6). The main types of tasks that were used include click, drag, notepad writing and multiple choice. Multiple choice and click are the easiest to construct, both for the scriptwriter and programmer, but should be combined with other task types to ensure maximum interactivity. Each task is designed according to the learning objective of the unit. For example, in the Listening Unit, tasks are diagnosed as vocabulary, main ideas, key words, summary, predictions or inferences. When choosing the frequency and placement of tasks, Orr, Golas & Yao [17] advise including an option for an interactive task every three of four screens, or once every minute. Yet designers should avoid a strict adherence to any formula for interactivity, as it depends entirely on the content, style and complexity of the material being presented. "You cannot gauge the amount of active involvement in a technology product by the number of mouse clicks, and ... similarly, one cannot assess learning by overall level of activity" [26].

The binary structure of the computer makes the process of task-writing an interesting and difficult endeavor. The scriptwriter is faced with the challenge of creating insightful, thought provoking tasks that elicit predictable, quantifiable responses. Where a teacher may be able to judge the validity of a multiple range of answers, a computer cannot. It is therefore up to the scriptwriter to predict all of the potential responses, a challenge especially for tasks that allow users to type responses in an open-ended format. During the piloting of VLU, for instance, it was observed that certain open-ended questions caused frustration among students who believed their answer to be correct - and if judged by a real-life teacher, may well have been. It is for this reason that questions with vague, complex or multiple responses must be constructed with great care.

How, then, can multimedia tasks be written without oversimplifying multifaceted and in-depth subject matter? This has been one of the leading criticisms of multimedia development as it expands to cover the more concept-based material within higher education. Users may get an unwarranted sense of having mastered a complex subject after correctly answering a complete set of computerized quizzes and close-ended questions [14]. One method of avoiding such a compartmentalization of information is allowing students to write down their own opinions on a profound subject matter using a computerized notepad. In VLU, this non-graded task is used to elicit predictions of what the lecture could entail, or personal opinions that the student may have. In this way, students are encouraged to contribute their own ideas and thus are able to build confidence in their analytical skills. The producers of the interactive multimedia package *Investigating Lake Iluka* argue that the notepad facilitates cognitive self-management by allowing students "to collect and manage information from a variety of different sources" [6]. This is substantiated by Laurillard [14], whose case study found that students appreciated "being forced, or perhaps enabled, to consider and develop their own analysis first, before seeing what the expert has written".

3 Design Issues

3.1 Screen design

Interactive media places users in a one-on-one relationship with a program that can be as intimate, or more intimate than, a face-to-face exchange [22]. For that reason, it is the task of educational multimedia producers to transform that relationship into a successful learning experience. In a user-controlled environment that enables students to turn off the program whenever they want, screen design becomes essential to maintaining learner motivation. Effective screen design allows for maximum learning from the materials while providing the learner with appropriate control of the learning process [16]. This could be compared to the teacher's role at the beginning of a traditional classroom setting. An effective screen design sets the stage for meaningful 'deep learning' to take place and motivates the student to stay engaged. The signs of a poorly designed screen are cluttered displays, complex and tedious procedures, inadequate command languages, inconsistent sequences of action and insufficient informative feedback [20]. Such designs can lead to anxiety, poor performance and dissatisfaction with the program. Some researchers recommend limiting the amount of text on screen to three lines in order to prevent information overload [4]. Users are most effectively able to concentrate on the multimedia material when the screen is made user-friendly with consistent commands and positioning of buttons. The importance of the screen design is corroborated by a number of researchers [21], [1]; [23]; [8].

The choices for screen design are endless, but the two basic extremes are simple and complex. There are both advantages and disadvantages for either consideration. The primary advantage of keeping the screen 'simple and uncluttered' is that it is less likely that users will suffer from immediate sensory 'overload.' As Stemler points out, multimedia instruction packages can become "nightmares when designers try to dump anything and everything into a single program simply because the capability is there" [21]. Most researchers agree with this approach [17]; [18]; [19].

In many cases, a thoughtfully designed complex interface will hold the user's attention longer. The use of a metaphor is one way of integrating a number of complex features with a simple visual structure and provides users with a sense of place, familiarity and ease of use. Within VLU, the metaphor of campus buildings is employed to distinguish between the four sections of the program: Grammar, Listening, Vocabulary and Writing. This metaphor is also useful for selection of the three levels of difficulty within the program. After diagnosis, the users take an elevator to the appropriate level of the unit they are working in.

3.2 Navigation

Unlike passive approaches to education, in student-centered learning, users navigate the path of their own learning. Because of this, the navigation design of a program determines the level of interactivity users will experience. There is a delicate balance between giving enough sense of direction to avoid anxiety, without over-directing users. It is important for users to always know where they are going. Too much freedom may result in students reviewing material or completing tasks that are not relevant to their purpose. According to the findings of Laurillard, learners working on interactive media lacking a clear narrative structure will display learning behavior that is generally unfocused and inconclusive. Learner control, one of the key benefits of interactive media, thus becomes pedagogically disadvantageous if it results in mere absence of structure [14]. While the users should be provided with sufficient choice through hypermedia links, there needs to be a balance between jumping around and sticking to one task [5]. According to Wild and Quinn, the ideal combination is "scaffolded reflection", that is, navigation that encourages thinking without losing the focus of the instruction [24].

There are several possibilities for how users access materials: sequentially, semi-directed, free choice or through pathways. Each of these methods can be designed to have extreme linear order or extreme non-linear order where users have little or no chance of deviating from a predetermined sequence. Thus,

package possibilities can range from strict, prescribed, sequential learning to complete freedom of choice. An alternative is a semi-directed program, allowing for the possibility of choice within certain situations.

Users can be given the option of skipping ahead only when a task is finished or they can be allowed to skip ahead at any time. Common procedure is to have the exit function or menu function available to users at all times. This implies that the navigation has minimal travelling; that is, express pathways so users arrive at their desired destination as fast as possible with little or no redundancy. In contrast, users may not be given the option of skipping at all but can only exit when a particular task/topic/section/unit is finished. Kristof & Satran suggest that users should not have multiple paths to any particular location because this causes confusion [11].

In VLU, users can chose to skip ahead to sub-topics at any time, yet are required to select the Main Menu to do so. Thus, while students can jump around to any building or level, they automatically enter a linear sequence once they have chosen a particular lesson (unless they click on the Main Menu, which is available at all times). This is particularly true for the Grammar section, where skipping ahead may mean missing important grammatical rules and explanations. In this section, students choosing to skip ahead will hear a friendly reminder from the animated host: "You are not advised to go to this task at this stage". Users are then given the option of proceeding anyway, or returning to the previous section.

3.3 User Feedback

Within the interactive format, the educational value of a program is directly linked to the style and quality of user feedback. The users can receive either immediate or delayed feedback to responses or actions. Immediate feedback lets the users have only one attempt at providing correct information, or making a decision. Delayed feedback, in contrast, allows the users to have a longer learning experience, an experience which requires completion of one or more steps before the users receive any feedback.

Feedback can also range from: i) individualized feedback which is based upon individual choice and performance, ii) to a more general response which addresses content considerations, iii) to a type of scoring (percentage, grade, written comments). Personal feedback can be created to address users by name and either make suggestions or critique decisions made. In VLU, the computer greets users by name as they enter the program. Because most users tend to respond positively to being addressed individually, this is usually seen as a positive option [9].

3.4 Testing

Users can also be tested before, during, or after using a package. The test that precedes the work done in the package can be used as a diagnostic tool for the user. By diagnosing weaknesses or strengths, students can be directed to enter the program at an appropriate level of difficulty. Considerations on the nature of the test include whether or not the test should be timed, whether students should be able to choose the subject matter of the test and how long the test should be. The answer to these questions will depend upon the type of material being tested. Analytic material probably requires no time limit, whereas non-analytic material may need to be timed. A secondary consideration would be how many times a user can take a specific test. How often should tests in general be given? Once per unit? One test per section or per topic?

If testing is used, diagnosis will be more reliable if several tests have been taken; therefore, a bank of tests is useful. It follows then that each test must accurately assess the skills being tested and all tests must be equal in difficulty. The generation of tests can be accomplished by having a single bank of questions with the computer randomly selecting the questions. This will ensure that users do not duplicate test materials.

Testing within VLU is an option provided to users once they have entered one of the campus buildings. The test length varies according to each section, but averages about 15 minutes per unit. For example, upon entering the Listening Test area, users are presented with a pop-up menu that asks them to select a test in

their area of interest: Environment, English, Politics and Business or Social Issues. In this way, students are able to control their learning experience and are not penalized for a lack of knowledge in a particular area.

3.5 Scoring

Another question designers will need to address is what kind of report users will receive after completing a test or set of tasks. Does the program require written comments, percentage grades, or is a simple pass/fail more appropriate? Reporting can be automatic after each task, or the report can be accessed upon request. One extreme is for there to be no access to scores until the entire unit/section/package is completed; the other is for automatic reporting to occur whenever a task is completed. The feedback or report can be a numerical or graphic representation. There can be results posted on the screen, or they can be printed, or even saved to a disk. Another design possibility is to have a progress report after users have used the program for a specified period of time. The progress report can incorporate individual feedback or re-direction to an easier or more difficult level. Teachers may also want to have a network reporting option that automatically sends them the students' reports [9].

Within VLU, users are provided with a percentage grade for each task as well as an overall grade for the section completed. This provides users with a clear indication of their areas of weakness, whether it be in specific grammatical structures, writing topic sentences, listening for key words or creating compound nouns. A rating of "good", "average" or "poor" is also given, with 80 percent or higher being good, 79 to 50 as average and below 49 as poor. With this method of reporting, users are oriented within the tri-level system of the program and provided with goals for motivating improvement.

Conclusions

As multimedia producers, our goal is to harness the power of emerging technologies to achieve our educational objectives. With proper planning and design implementation, producers can not only simulate the classroom setting, but enhance it - and thus contribute to an overall rise in the level of educational standards. As Kozma points out, our ability to take full advantage of new technologies depends on the creativity of designers and our understanding of the relationship between these capabilities and learning [10]. This becomes especially important as computer-based multimedia becomes a ubiquitous aspect to learning at all levels [12]; [2]; [7].

This paper has discussed some of the issues involved in designing interactive courseware, with an emphasis on the Higher Education environment. The authors have attempted to use the experience of VLU to identify some of the key challenges involved in the various stages of multimedia design: development environment, design, user feedback and piloting. One of the greatest challenges involved in multimedia design is integrating the freedom-of-choice that makes interactivity what it is, without straying too far away from the sensible guidance necessary for any valuable educational endeavor. Designers are being challenged to create a learning environment that combines learner controlled browsing within a system-encouraged structure. As demonstrated in VLU, this bipolar dynamic is evident in almost every stage of the production process - from navigation to taskwriting to the integration of audio and visual effects. Every interactive learning production has its own set of problems and challenges, which is perhaps what makes multimedia design such an exciting and creative field to be working in. The lessons gained from VLU will continue to improve the program as it is exposed to more users and teachers, and as the development team generate new ideas for a revised version. It is hoped that these insights will contribute to the growing source of knowledge on multimedia design and ultimately lead to better products for students.

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Design of Multiple Metaphors in User-Interface

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As computer systems have become more sophisticated, several researchers have proposed the use of multiple models or metaphors to design computer systems and have argued that the provision of multiple metaphors would better match the characteristics of complex target systems. Multiple metaphors refer to the use of two or more distinct metaphors, each explaining various aspects of the target system. A multiple-metaphor interface means the combination of two or more metaphors to design the interface for a computer system. Although we see the strength of using multiple metaphors in interface design, not many guidelines for selecting and combining metaphors in creating a system are available. Because of the present vogue for interface metaphors and the limited research available in this area, there is no accepted standard for designing metaphorical interfaces. In this paper, the theoretical basis for the use of multiple metaphors is discussed. The method in designing metaphorical interfaces is proposed as the author created the interfaces for a metaphor study. Issues of metaphorical interface design are discussed and detailed procedures in generating and combining metaphors in creating interfaces for a hypermedia system are presented.

Keywords: **Multiple metaphors, analogy, structural cues, interface design guidelines**

1 Introduction

Metaphor is traditionally a concept belonging to the fields of linguistics and philosophy. In 1980, Lakoff and Johnson [1] presented new ways of thinking about metaphor regarding everyday experience. They consider the essence of metaphor to be "understanding and experiencing one kind of thing in terms of another" (p. 5). They demonstrate that people's conceptual systems are metaphorical and people's actions every day are a matter of metaphor. In human-computer interaction, a metaphor is "present when terminology or concepts from a familiar non-computer domain are used to depict computer functions and objects in a user interface" [2]. Two components of a metaphor are the base domain and the target domain. The base domain is "the area of knowledge or expertise which a person already possesses," while the target domain is "the area of knowledge or expertise in which a person is trying to become familiar" [2]. When a computer user learns a new computer program, he calls upon his prior knowledge (analogies or metaphors) as the basis on which to form a new mental model. Designers can take advantage of users' existing mental models to present ways of conceptualizing computer functions and to design interfaces for computing systems [3]. Carroll, Mack, and Kellogg [4] describe the use of metaphor as a way to control the complexity of user interfaces by designing the actions, procedures, and concepts of new interfaces based on users' familiar actions, procedures, and concepts from previously learned interfaces. Metaphors used in this way are called interface metaphors.

Because humans learn new concepts or knowledge in terms of what they already know, almost all the computer interfaces in the world contain various types of metaphors taken from other domains. The current concern in computer interface design for ease of use, encourages the use of familiar objects and icon-based operations. Using these, computer users do not have to interact with command line syntax like they did before. This trend also facilitates the growth of the Internet [5]. Ratzan [5] argues that "metaphors may themselves suggest further implications, inferences or interactions of computer components. Metaphors help make sense of the online environment" (p. 47). Nevertheless, design guidelines derived from research findings on Internet metaphors are far behind their present demand in the practitioner field.

2 The use of multiple metaphors in interface design

While metaphor is useful for helping people to reason about new knowledge, mismatches between the base and target domains may occur, which lead to incorrect inferences. Carroll, Mack, Kellogg [4] claim that metaphor must provide incomplete mappings to their target domains. "If a text editor truly appeared and functioned as a typewriter in every detail, it would be a typewriter" (p. 69). Mismatches happen in situations in which the attributes and relations of a single metaphor can not be perfectly correlated with the attributes and relations of the target domain. This is especially true when the target domain is so complex that no individual model can fully explain anticipated behavior. In this case, the use of multiple metaphors to design interfaces may be a solution [6]. Benking and Judge [7] explain that three or more complementary metaphors may be used together in order to adequately represent some complex systems. Booth's [8] argument provides a basis for the use of multiple metaphors. He notes that people "appear to have blocks of knowledge relating to different domains and use parts of these knowledge blocks when they believe that it is appropriate" (p. 73). One kind of composite metaphor (multiple metaphor) is the use of complementary metaphors to represent functions of an interface, with each metaphor representing a function at a single level. Carroll et al. give an example of this kind of composite metaphor -- the integrated office system, which includes electronic mail, spreadsheets, text editing, and decision support, each with a different metaphor to represent it in the system.

In terms of the theoretical basis for multiple metaphors, Rumelhart and Norman [9] conducted a study on teaching new users to learn a text editor. They observed that students made errors because of their inadequate conceptualization of the various parts of the computer system. This resulted from the insufficient mental models students brought to the situation; they limited the kinds of analogies they might have employed. The authors note that no single metaphor can fully explain a complex piece of subject matter. Thus, they postulate an effective solution to eliminate student errors -- the provision of a more appropriate analogical framework, with different conceptual models to help students in their reasoning. They developed the "secretary," the "card file," and the "tape recorder" models, each explaining various aspects of the text editor, and claim that, although none of the models are perfect, as people grow more experienced in a domain, they become better at choosing appropriate models for a specific situation. In teaching this subject matter, it is effective to present a set of models, each with their own built-in context dependencies, as alternative conceptualizations of the target domain.

Collins and Gentner [10, 11] found that analogies allow people to create multiple mental models for use in reasoning about a complex system. They discuss Gentner's [12] analogy hypothesis and note that "a major way in which people reason about unfamiliar domains is through analogical mappings" (p. 247). They used analogies to map the set of transition rules from a known domain (the base) into the new domain (the target), thereby constructing a mental model that can generate inferences in the target domain. To test this hypothesis, they observed how subjects reason about evaporation and did an analysis of their protocols. The qualitative data suggests that subjects formed three different levels of interrelated mental models in reasoning about the target domain. These findings support the view that people learn the target domain by partitioning it into different component models, each mapped to a different base domain.

Multiple metaphors have also been employed in the field of artificial intelligence. Burstein [13] presented a model for students to learn a programming language. This involved the use of a box analogy, an algebra analogy, and a human processor analogy. In the example, the author used analogies in such a way that each analogy covered several levels of description, but served different functions. The use of multiple analogy models has been found to be more helpful in facilitating students who are learning the new domain in this case.

Spiro et al. [14] describe the danger of using single analogies in learning and instruction. They suggest that misconceptions are often caused by the reductive effect of analogies. "When analogies are used to 'start simple,' the knowledge ultimately acquired often stays simple. Well-intended analogies often result in oversimplified knowledge" (p. 502). They present eight situations in which the use of an analogy induces misconceptions or mismatches. One common characteristic of these eight situations is that users tend to depend too much on the properties of an analogous source domain in understanding the topic (target) domain. To solve this problem, they propose an antidote -- the use of integrated multiple analogies to represent complex concepts. They claim that by introducing new analogies which emend the missing or misleading aspects of the earlier analogy, the strength of the original analogy is retained, but its weakness is discarded. To give an example, muscle fiber function is proposed as the target concept, which is then explained by three analogies -- the rowing crew, the turnbuckle, and the Chinese finger-cuffs analogies. To integrate multiple analogies, they propose the technique of "composite imaging with selective contingent instantiation" (p. 522), in which three analogy models are created separately for the comprehension of the muscle fiber function with

the applicability of the elements in each analogy being context-dependent. Although the authors claim that this technique could be applied mentally or to computer graphic displays, its implications for the design of a composite metaphor are limited.

The advantage of using multiple metaphors in designing computer interfaces can be seen. However, there is no accepted standard for designing an interface with multiple metaphors. In the following section, the issues or problems of designing a multiple-metaphor interface will be discussed.

3 Issues to consider in the design of multiple (composite) metaphor interfaces

Judging from previous studies [15, 2] and my experience, I conclude a number of difficulties that designers or researchers would face in creating a multiple metaphor interface. Since the generation of a multiple metaphor interface involves the selection and combination of multiple metaphors, design considerations and problems will be discussed below within these two phases.

3.1 Selection of metaphor

When selecting metaphors to design interfaces for computer systems, the designer needs to consider several issues, which include the type of information, description level of metaphors, users' expert levels and prior knowledge, users' tasks, methods of task completion, and appearance of the interface.

* The *type and structure of information* of the target system influences how designers select metaphors. These attributes include the information content and structure of the target system. Designers need to consider the type of content information when choosing appropriate metaphors.

* In terms of *description level* of the target system, Booth [8] claims that "the level of description of a metaphor is concerned with the type of information that a metaphor might be expected to communicate" (p. 77). He takes an example from Moran's [16] Command Language Grammar and says that a metaphor can be aimed at the task level, the semantic level, the syntactic level, or the physical level. This characteristic increases possibilities, but also the difficulty in designing a metaphorical interface.

* When choosing metaphors, the designer should consider *users' prior knowledge* in their familiar domains as a basis for designing tools for learning new things. Stagger and Norcio [17] claims that, when designing multiple models for users to learn new knowledge, designers need to consider the expert level of the users and the tasks to be completed. As users gain expertise in the target area, their ability to manipulate multiple models increases. Since metaphors work by mapping previously acquired knowledge of users to the target domain that they are going to learn, some attributes (objects, relations, actions, effects) of the base domain must match with the attributes of the target domain. The selection of metaphors should be based on a user's familiar knowledge.

* Carroll et al. [4] explain three aspects to consider in designing a metaphor: the *tasks, methods, and appearance levels.* The task level describes users' goals and what they can do; an example is the information search in the present study. The method level describes how tasks are accomplished. The appearance level is the "look and feel of the task situation vis-à-vis the physical implementation of the domain" (p. 78). It includes aspects of the hardware and the presentation of screen objects.

In addition to consideration of the above criteria in selecting interface metaphors, designers also face some design problems described by Cooper [18]: 1) there are not enough metaphors; 2) the metaphors do not scale well; and 3) the ability of users to recognize them is questionable. As the number of metaphors increases in designing an interface, there are more constraints regarding the criteria of metaphor selection. Carroll and Thomas [3] suggest that when using two or more metaphors to design a system, one should not choose objects or procedures that are exclusively alternative to each other, so as to avoid interference and confusion. In another article [19], Carroll and Mack argue that good metaphors should also not provide completely transparent and comprehensive mapping, so that they may better enable users to learn.

3.2 Combination of metaphors

Once multiple metaphors are selected, designers need to identify an optimal way of combining the metaphors. This issue has not been well discussed by scholars, so there are not many guidelines regarding how to combine multiple metaphors to create a computer interface.

Beyond the issues discussed above, designers face some additional problems in combining multiple metaphors. First, it is hard to draw the boundaries between different metaphors. Booth [8] raises this question for designers: "how [can we] signpost the boundaries of metaphors within a system so that users know when a metaphor is no longer relevant and when another metaphor is appropriate [?]"(p. 78) Second, although the idea of using multiple metaphors has been suggested for interface design by practitioners, the way to operationalize multiple metaphors to create interfaces is very difficult to carry out. Most previous studies used separate analogies to teach new knowledge, or they used separate metaphorical interfaces to help users to learn new computer systems. Methods for combining different metaphors in a system have not been explored. Smilowitz [2] was a pioneering researcher who tried to mix two metaphors in an interface in her experimental studies. Due to the challenging nature of this case, there were design deficiencies in her approach to combining multiple metaphors. Smilowitz tried to mix two metaphors within the navigation area in a hypertext system. But navigation tools are only a part of an interface. The design in her study limits users' perceptions of the metaphorical interface.

In light of the above difficulties, the application of structural cues taken from multiple metaphors may be a solution to integrate two or more metaphors in designing an interface. The next section is a brief review on structural cues in computer interfaces.

4 Hypertext structure cues

Dillon [20] presents a discussion on the structure in documents. He argues that the meaning of structure differs depending on different standpoints: from the perspectives of writers, readers, or from the consideration of reading/writing tasks. There is a difference in the structures of a paper and an electronic document. Compared to a paper document, a hypertext document does not have the same amount of information available to the readers, and its structures do not have equal transparency. In a hypertext system, the author can create numerous structures from the same information. Due to the lesser experience novice users may have with hypertext systems, "users' schemata of hypertext environments are likely to be 'informationally leaner' than those for paper documents" (p. 114). These reasons may explain why users easily become lost in hyperspace.

One way to solve navigation problems in hypermedia is to provide structure aids that inform users of what information is available, as well as where it may be located and how it may be organized. Hulley [21] discuss hypermedia and notes that "its structure needs to be made obvious to the users [,] and a means of browsing and navigating around it needs to be provided." In addition, he thinks that "the methods chosen for structuring information need to be the most suitable for the user's needs; they must support the tasks that the user wants to carry out and provide an interface which can be easily understood or learned" (p. 173). Thuring, Hannemann, and Haake [22] argue that the coherence of a hyperdocument has an impact on the reader's information processing. Well designed hypertext structures plus the presence of rhetorical cues may facilitate coherence; so designers should provide cues at both the node (within nodes) and net (between nodes) levels. Rouet and Levonen [23] describe the prototypical representation of hypertext as "a set of text units connected through multiple links, that is, a text network" (p. 15). Due to the navigation problems which a novice user may experience, they argue that novice users need analogies with conventional structures.

5 Procedures used to create multiple-metaphorical interfaces

From the literature review we know that a single metaphor does not cover everything in the interface. The use of two or more metaphors in designing an interface may be a solution for the problem of mismatch and may better represent the elements as well as the relations to the target system. In addition, structural cues or metaphors should be provided to hypermedia users for them to understand the way to navigate the system.

Because of the present vogue for interface metaphors and the limited research available in this area, there is no accepted standard for designing metaphorical interfaces. Interface design in this area is more laborious because of this problem concerning the operational definition of metaphorical interfaces. Due to the problems designers or researchers may experience when combining multiple metaphors to create an interface, the

creation of a metaphorical interface by combining structural cues that are derived from two or more metaphors may be a useful way to help users to search within a hypermedia system.

In my metaphor study, I compared single versus multiple-metaphor interfaces on their effects in facilitating users' information search behaviors in a hypermedia system. There were three interfaces as the independent variable in the study, with the first interface containing less metaphorical elements, the second containing some metaphorical elements from a single metaphor, and the third (multiple-metaphor interface) containing more metaphorical elements from two metaphors.

A method was proposed to create the metaphorical interfaces based on existing design guidelines and the revision of design methods used by other researchers. In this strategy, the metaphors work as the source for the structural cues to be combined in creating a metaphorical interface. Metaphors were used as the basis for deriving navigational cues, but those cues were not treated illustratively. In other words, the cues are related structurally to the metaphors but do not necessarily represent elements of the metaphors in a pictorial way. The metaphors used provided a logic for the designs, which guided the choice of structural cues that distinguish the three interfaces by the varying degrees to which they appear. This approach leads to a more precise operational definition and manipulation of the variables.

A detailed review of the method for creating the three interfaces for the experimental study is presented in the following paragraphs.

5.1 Selection of context and task for the study

In the study information searches were chosen to be the user task in order to investigate the effectiveness of using metaphors as a navigational aid in designing a hypermedia system.

5.2 Selection of information content (information system)

After the task had been chosen, the information content was identified based on the scope and structure of the system, the depth and width of the information structure, characteristics of the information related to the target system, the familiarity of the content to the potential subjects, the availability of the system, its ease of implementation, appropriate metaphors for this information content, and software used to create the hypertext system. These issues were identified partially through a review of articles describing the processes that other designers went through to create metaphorical interfaces and the criteria they took into account [24, 25, 26, 27, 28, 29]. The web sites of some universities, the web pages of the Library of Congress and the National Science Foundation, a CD-ROM in science, a health database, geography information, the lives of musicians, world art and wars, and American history were reviewed. Some systems were good because they have structures embedded within them for information searching and navigation; but there were no appropriate metaphors for those types of content. For the other systems, there were appropriate metaphors that matched the content or elements, but the information structures were not useful for information searching.

The CD-ROM "The Enduring Vision" [30] was finally chosen as the content on which to base the hypertext system. It contains 33 chapters of American history. The same content as that in the CD-ROM can be found in the book The Enduring Vision, and the CD-ROM structure is similar to the structure of the book. This similarity between the book and CD-ROM was a positive factor which influenced my choice of the CD-ROM. It made the job of creating the three variances of hypertext easier, because the content did not have to be restructured to fit the book metaphor. Four chapters with a total of ninety-eight articles in nineteenth-century American history were selected from the program to create the hypertext system.

5.3 Selection of metaphors

The chosen hypertext system placed constraints on the variety of possible metaphors that could be used to design the interfaces. The issues taken into account at this stage included the subjects' prior knowledge concerning the metaphors, the characteristics of hypermedia systems versus the attributes of metaphors, the overall structures of metaphors in covering hypermedia systems, the appropriateness of metaphors for information searching, potential mismatches between the metaphors and the hypermedia system, existing metaphors used in other software, ease of representation, manifestations /appearances of metaphors, guidelines for metaphor design, and methods of combining multiple metaphors. In addition, the characteristics proposed by Lin [15] were also taken into consideration. These are: (1) the style of presentation of information, (2) the size of information units, (3) the degree of user control over the ordering of information, (4) routes of

traversing, (5) the visibility of linkages among units, (6) the implied internal structure of information units, and (7) the style of access to specific information. Some other design guidelines were also taken into consideration when I created the metaphorical interfaces. After several unsuccessful attempts (using different combinations of multiple metaphors such as timeline, map, journey, path, container, building…), the book and folder metaphors were ultimately selected, based on the above guidelines and the consideration of possible ways of metaphor combination.

One criterion in selecting multiple metaphors is that the chosen metaphors must be independent of each other. In other words, one metaphor can not be a secondary (subordinate) metaphor to the other one (the primary metaphor). According to Cates [24], a primary metaphor refers to the principle or first metaphor employed, and a secondary metaphor means a subsequent metaphor employed. The secondary metaphor "stimulates images and semantic expressions related to those stimulated by the primary metaphors which they are intended to accompany."(p. 98) If one metaphor is subordinate to the other, then they can be seen as the same metaphor.

The reason I selected book and folder metaphors is that each could map to different aspects of the hypermedia system, so they are complementary (see Table 1 for analysis of metaphor functions). Spiro et al. [14] propose the employment of multiple analogies in learning and instruction. They identify eight ways that analogies may induce misconceptions. Based on their framework, I analyzed the strengths and weaknesses of book and folder metaphors and used them in the design of three interfaces. Due to the scope of this paper, this analysis will not be discussed in the current paper.

Table 1: Analysis of metaphor functions and structural cues

	Elements related to content or to the hypermedia structure	**Metaphor functions related to hypermedia characteristics**
Book metaphor	• Books have structure. Each book page can be used to place an information unit (e.g. a web page) • A book has a cover, a table of contents, chapters, sections, and pages • Turn page/ page number • Open/close a book	• There is visibility of linkages among units • A book structure implies the internal structure of information unit in a hypertext system • A book has a particular style of information presentation and access to specific information • Book pages need to be accessed sequentially by page turning or by reading the table of contents (Lin, 1989, p. 48)
Folder metaphor	• Each folder can be used to place an information unit • Folder tabs with labels enable users to easily identify the content of a folder • Flexible ordering of information (Lin, 1989, p.46)	• Folder tabs allow random access to specific information units (Lin, 1989, p. 46) • Information units in different levels can be directly accessed

5.4 Combination of two metaphors and the creation of three interfaces (use of structural cues)

After each metaphor was selected, all of their objects and functions were analyzed using the POPIT model as shown in Table 2 [24]. The design problems which previous researchers faced in combining multiple metaphors in one interface (the creation of a composite metaphor interface) have been discussed in previous sections. In addition, Lakoff and Johnson [1] claim that "metaphors do not imply a complete mapping of every concrete detail of one object or situation onto another; rather they emphasize certain features and suppress others" (p. 96). It is also impossible to manipulate metaphorical elements in an interface from complete absence to presence.

In view of these difficulties, the three metaphorical interfaces were created in such a way that each interface contains various degrees of structural cues taken from one or two metaphors, with the cues ranging from minimum to maximum. Rather than call them the no-metaphor, single-metaphor, and multiple-metaphor

interfaces as in previous studies, they were called "the interfaces with different degrees of structural cues derived from single or multiple metaphors."

Table 2: POPIT Model (Cates, 1994)

	Book (Cates, 1994)	Folder
Properties	Book cover, pages, table of contents, chapters, sections, title	Tabs on the top of each folder, several folders can be put together, labels or keywords on the tabs
Operations	Open or close a book, turn page forward and backward	Folder tabs can be thumbed through, it allows random access, flexible ordering of folders
Phases	Turn pages, open, close, begin reading, find information/words, highlight	Select the folder, open the folder, select section by way of thumb tabs
Images	Book cover, layout of books	Same size and shape for each folder, tab in different location on the top, tabs have different colors
Types	Reference works, recreational books	Information storage

First interface (interface A with minimal cues)

There were a total of one hundred screens in this interface. Interface A contains a minimal degree of metaphorical concepts. In addition, the three interfaces in this experimental study needed to have similar structures and styles of information presentation for the sake of comparison and data collection. Since all computer interfaces contain some degree of metaphors taken from other domains, it is impossible to rule out metaphor elements totally. In the hypertext system, each article was organized hierarchically with its title listed in previous levels as hyperlinks. This made the title lists look more like the content lists of a book. For this reason, interface A still contains a small number of metaphorical elements, partially due to the nature of the information content.

Second interface (interface B with medium cues)

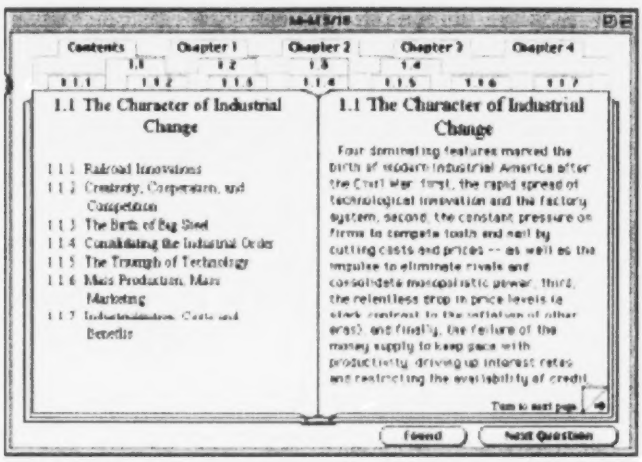
There were a total of four hundred and twenty seven screens in each of the interfaces, B and C. The same structural components and elements can be found in all three interfaces: 1) four levels in the system, 2) a main page as the first level with hyperlinks linking to the second and the third level, 3) articles in the second, the third, and the fourth levels with or without hyperlinks linking to the next level, and 4) titles and body text for each article. Based on the analysis, terms, images, structures, and operations were taken from a book metaphor to add to the design of the second interface. This causes the second interface to contain more structural cues from a book metaphor. All the information was presented in book format; for example, the text of each article was presented on double-sided pages, as in a real book. Users can click on the dog-ear to turn to the previous or next page. In addition, the title of each article was labeled with chapter, section, and subsection number to resemble the title of a book.

Third interface (interface C with maximum cues)

In order to compare the effects of the interface in which the structural cues were taken from only one metaphor with the interface in which structural cues were taken from multiple metaphors, a third interface was created (see Figure 1). Extra structural cues, including images, structures, and operations of a folder metaphor, were added to the second interface to create the third one. Whereas information presentation in a book metaphor is linear, the folder metaphor conveys the hypermedia attribute of flexible information access. The book metaphor worked as the main metaphor and was broader in its scope, while the folder metaphor was added to the design to supplement the book metaphor. Booth [8] describes the dimensions of a metaphor in terms of its scope and level of description. The scope describes the number of concepts that a metaphor addresses, and the level of description deals with the information types that a metaphor communicates. Similarly, Hammond and Allinson [30] describe four levels of information that a metaphor may convey: task information, semantic information, lexical information, and physical information. Using those concepts to examine the design in the present study, the book metaphor has a larger scope and it conveys four information levels: the hypertext structure, the layout, the terms, and the operations; but the scope and information levels of the folder metaphor are more restricted. The main function of the folder metaphor is to provide a flexible means of information access so that users can randomly access articles in different levels.

The structural cues taken from the book and folder metaphors include content lists, section titles and number, double-paged layout, book turning corners, folder labels with section numbers, physical layouts of book and folder metaphors, and so on. Those elements consist of textual and graphical structural cues, which were combined to create the metaphorical interfaces.

Figure 1. Screen-shot of the third level for interface C (multiple-metaphor interface)



6 Conclusion

Metaphors do not apply equally in the interface designs, and usually only the most salient points are drawn from a metaphor. The book and folder metaphors are not alternative choices; instead, they complement each other (in a non-exhaustive way). This is consistent with Benking and Judge's [7] view of using three or more complementary metaphors to explain complex systems. Due to the consideration of ease of manipulation in the experimental study, only two metaphors were chosen for the design of the interfaces. At each step in creating the interfaces, not only more possibilities, but also a few constraints were added to the design. The selection and combination of the structural cues did not result in perfect designs, but they were completed with much deliberation concerning the many design possibilities and tradeoffs.

Designing metaphorical interfaces involves many other issues that are beyond the scope of the present discussion. The compatibility between the metaphors to be combined may play an important role in appropriately conveying the functions of each of the interface elements. Interfaces that are created with incompatible metaphors could cause misunderstanding and hinder users' performances. The problems of selecting and combining multiple metaphors have been discussed in this paper, and the procedures for creating the metaphorical interfaces have been explicitly presented. There are many complex design issues involved in the creation of metaphorical interfaces. The design of a metaphorical interface relies on appropriate metaphor selection and combination in order to achieve optimal effects. Further research is needed to explore other possible ways to combine multiple metaphors to create user-friendly interfaces.

Due to the scope of this paper, the whole process of creating metaphorical interfaces can not be discussed in detail. However, it is the hope of the author that the method presented can provide interface designers and researchers with insight in creating metaphorical interfaces.

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Development of 3D simulation programs for classical mechanics - Using Java 3D -

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1 Introduction

As LAN and Internet have diffused in recent years, environments of computers have been well filled and computers have become more popular among students. These developments make it possible for the style of education of physics to become various.

Recently many groups develop simulation programs for education of physics. We develop simulation programs for physics education using C language, XForms and Mesa library on Linux computer [1]. There are not only 2D but also 3D simulation programs. These programs are used in physics experiments for students [2,3]. One of the weak points of our system is a difficulty for opening our programs to the public. Only students attending the class can execute the programs.

On the other hand many programs coded by Java are also proposed and an education environment are prepared on the Internet. On World Wide Web (WWW), there are many programs coded by Java that are opened to the public [4,5]. Condensed Matter Theory Group of Kyushu University in Japan opens a virtual laboratory for the introduction of physics on WWW [6]. In the laboratory one can study physics with a simulation and an explanation for it. It is very good idea to open the programs to the public through Internet, but most of those programs are for 2D simulation. We think that 3D simulation is more exciting and is more helpful for understanding the motion of objects, because 3D simulation is more realistic.

Our aim of this study is to develop 3D simulation programs and open them to the public through Internet. We develop programs using Java in order for as many as people to utilize them and make use of Java 3D API for realizing 3D visualization. To our knowledge, there are still only a few programs proposed for education with use of Java.

2 Environment of development and execution

Our simulation programs are developed on an IBM PC/AT compatible computer. We adopt Linux as an operating system (OS) and XFree86 3.3.6 for X Window system. Java 2 SDK v 1.2.2 for Linux Production Release, Java 3D 1.1.3 API and Mesa 3.1 are used for developing applications. One of the reasons for adopting Linux is that Linux system has a reputation for its stability. Although applications are developed on a computer with Linux operating system, one can use any kind of computers and operating systems for execution of applications. This is merit and what we aim for in developing applications.

3 Example

We developed some programs with use of Java and Java3D by way of trial. One of them is a simulation of motions of ball in a box under gravitation, whose snapshot is shown in figure 1. We list below special features of these applications.

- We make use of Swing API for graphical user interface (GUI). Swing is provided as one of the standard APIs in Java2 and we can develop applications with common GUI operations in total independence of a kind of a computer and OS using Swing API.
- One can execute programs not only as an application on a local computer but also as an applet on a

browser through Internet. Java Plug-in is necessary for executing programs on a browser in the present. However this restriction will be solved in the future.

- Real-time simulations can be realized with use of thread class of Java. Furthermore, one can execute applications in slow-motion mode and in fast-forwarding mode.
- Java3D uses a tree structure for realizing 3D visualization. By changing branches and leaves, objects can be moved, transformed, replaced and so on.
- Java is a class-based object-oriented programming language. Therefore we can easily add or remove objects. Furthermore rules of motion can be specified to objects. Then we can realize various motions of objects.
- Since Java2 is prepared for Unicode and Locale, internationalized programs can be developed.

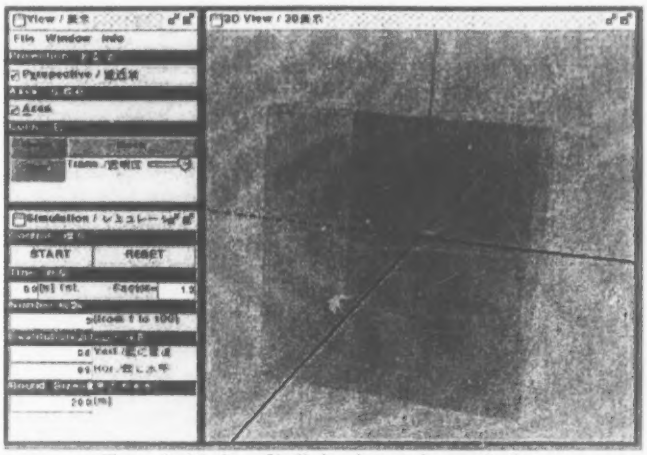

Figure 1. Motion of balls in a box under gravitation.

4 Conclusions

We propose an educational system for elementary physics with use of Java and Java 3D API. Our system offers 3D simulation programs with use of Java 3D. 3D visualization of the system of classical mechanics helps students to understand the behavior of the system and to have interests in physics. Since our programs are developed by Java, anyone who has an environment of Java can execute them on WWW. Therefore we can open our programs to the public and we can receive responses and evaluations for our programs. Note that one needs Java Plug-in for execution of our programs in the present. In the future, we want to increase the number of simulation programs and open those programs to the public.

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Evaluating educational multimedia: a case study

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Following constructionist principles, postgraduate students who were studying a paper on Human Computer Interaction were required to build educational multimedia systems and then to evaluate those produced by their colleagues. The experience of developing a multimedia system, together with lectures and access to general material on the topic, enabled them to provide valuable insights into important issues. Nonetheless, the students were not, on the whole, able to transfer all that they had learned when building their own systems into an evaluation framework. The provision of scaffolding was recommended to facilitate transfer.

Keywords: **Multimedia, Evaluation, Constructionism**

1 Introduction

What are the criteria that should be used to judge the effectiveness of interfaces for multimedia tutorial systems? In an experiment with a class of postgraduate students studying Human Computer Interaction (HCI), they were asked to develop their own framework for evaluation. To give them some notion of what to look for and what to expect, they first had to form groups and construct their own multimedia tutorial systems. This approach is based on the idea of constructionism [6]. By collaborating in a group to develop some appropriate product, it is suggested that learners can come to a better understanding of the principles of a subject rather than by just being given the information by a teacher. This is in line with the wry comment from Jonassen *et al* [9] that the people who learn most from instructional materials are the designers.

The students were required to work together with one or two other classmates to produce their own small scale multimedia educational systems. Using the knowledge and experience they had gained, they then had to individually evaluate the interfaces of the other systems. There was no detailed specification about how to carry out these activities. The students had, however, been exposed to the main issues through lectures and discussions. They also had appropriate readings made available to them. The intention, therefore, was to see what the students, themselves, considered appropriate ways of evaluation in the light of their background and their experience in developing multimedia software. An assessment was then made of how much they had learned when building systems and how well the knowledge was applied to evaluating the systems of others.

2 Previous work

Interface evaluation can be carried out for many different purposes. The distinction is usually made between formative evaluation where improvements to a system under development can be determined and summative evaluation which assesses the overall performance [8]. There are a range of methods that can be used depending on the purpose of the study. Preece [12] categorises these purposes as analytic, expert, observational, survey and experimental. Analytic techniques are used to determine the complexity of the interfaces. Expert evaluation involves inviting people experienced with interface issues to identify usability problems. Observational, survey and experimental studies all have in common the involvement of what Preece terms "Real users." Users can be observed using software, provide feedback about the system through interviews or questionnaires or take part in experiments to test the impact of various features of the interface.

A common method of evaluation that does not involve users is expert evaluation where, as noted above, people

with some knowledge of interface issues detect possible problems. This process can be conducted in accordance with the guidelines formulated by Nielsen and Molich [11]. The following aspects of the interface are all considered in what is referred to by these authors as a heuristic evaluation: simple and natural dialogue; speaking the user' s language; minimising user memory load; consistency; feedback; clearly marked exits; short cuts; good error messages; prevention of errors, and help and documentation.

An examination of the literature on multimedia reveals little mention of evaluation. Testing is usually discussed but not evaluation [4, 15]. Some important principles emerge, however. Alty [1, p33] points out that "A key question is when to use which media and in what combination to achieve the maximum effect." He also observes that success in multimedia depends more on the *combination* of media rather than on the provision of a rich set of media. Frater and Paulissen [5] note that interactive tutorials should allow the user to choose the starting point and allow the information to be accessed as often as required. They also offer this piece of advice. "Keep in mind that multimedia can make learning much more interesting when animation and sound files are used to explain the topic. Also a quiz is more fun when set up as a game" [5, p362]. Preece [12] points out that navigation, too, is an important consideration in hypertext/multimedia systems. Users, as she notes need to be able to know where they are, how they reached that point, where can they go next and how they get there. This as pect of interface design is actually covered by the first heuristic of Nielsen and Molich [11] which refers to "Simple and natural dialogue." This takes into account navigating through a system. Interface factors in interactive multimedia systems are also considered in Reeves and Harmon [13] and Tannenbaum [14].

One recent taxonomy in the literature provided by Heller and Martin [7] aims to help students on multimedia courses understand the forms of media as well as enabling them to evaluate the work of others. It has two dimensions - the media type and the means of expression (elaboration, representation and abstraction). This classification shows, for example, that text might be fully elaborated (large chunks of narrative), can be abbreviated (represented in bullet points) or might be abstract in nature such as text in a logo. Students are able to check whether a medium has been used in an appropriate fashion. As the authors state, though, the taxonomy takes no account of the effect of combining several media. Nonetheless, it is useful in focusing on the evaluation of each element. Detailed guidelines about how to use each medium, for example text, can also be found in Vaughan [15] and Collins [2].

3 Course structure

"Topics in Human-Computer Interaction" is a single semester paper for postgraduate students in Computer Science and Information Systems at Massey University. Most students have already completed a third year undergraduate paper "Human-Computer Interaction" in which the underlying theory is presented. These students will also have gained some experience in developing interfaces. The aim of this course is to consider issues of current interest such as computer supported co-operative work, innovative interfaces, different ways of evaluating the interface, multimedia systems and interfaces on the World Wide Web. Teaching is carried out through a mixture of lecturing, student seminars, discussion and demonstrations (of software such as Adobe Premiere and Macromedia Director). Students have available to them two books of readings which cover the material taught.

One assignment for this paper involved the students working in groups to develop a small multimedia system with an educational focus. The groups could choose any appropriate subject. Each student was then asked, individually, to evaluate the interfaces to all the other systems. A set of lectures had been given on the topic of multimedia including exposure to several life cycles for developing software of this kind. The topic of evaluation had also received considerable coverage in lectures and student seminars. Students were aware that interfaces can be evaluated for various purposes and in many different ways (for example by heuristic evaluation, interviews, questionnaires etc.)

Guidance on the life cycle that should be followed to develop the multimedia systems and the method of evaluation required was deliberately kept to a minimum. In the light of the teaching on the course and the material available to them, students were expected to make their own informed decisions. In particular, it was hoped that the students' own experiences in developing multi-media software would give them some insight into the criteria that should be employed when evaluating the interfaces to the other students' systems.

4 The student systems

Six groups each developed their own multimedia system. The systems were expected to offer instruction to their users and be interactive. A brief description of the systems follows.

Maori Language Tutoring

This system was designed to help students learn the Maori language. The study material was based on the philosophy that Maori be used wherever possible, with visual and aural stimuli to teach the vocabulary. Words were introduced via demonstrations using pre-recorded video clips. The system, however, also contained explanation in English for students who did not wish to completely immerse themselves in Maori. As well as learning new terms, students could choose to review vocabulary or test their comprehension. Maori music and designs were used in this system where the developers thought appropriate.

Learning the New Zealand Road Code

A written test on the New Zealand road code has to be passed before learner drivers can take their practical driving test. The aim of the road code system was intended to make the learning process more interesting. It was believed that by using animation, audio and video, the learning process would be enhanced. The system included tutorial material on aspects of the road code (for example, how to overtake or what to do when approaching a roundabout) as well as test material.

Earthquake Disaster System

The earthquake disaster system was developed to show people how to behave in the event of a serious earthquake. It included clips from a video developed by Civil Defence. Topics that were dealt with included planning for and coping with an earthquake. The opening screen showed a photograph of the devastation caused by a major earthquake. Music and animation chosen to reflect the theme of devastation accompanied the photograph.

Shape Recognition

The intention of the shape recognition system was to help children learn how to identify both two and three dimensional shapes in a lively and interesting way. Sound, animation and graphics were included in order to make the system appealing to children. Another goal of the developers was to make the system easy to use. There was a particular emphasis on the use of colour which was seen by the developers as making the system attractive to the intended users. The opening screen was designed to capture the attention of children with music and morphing shapes.

Introducing the Internet

This system, as its name implies, was intended to be introductory in nature. Its target group was school children who could find out about concepts such as email, newsgroups, file transfer protocol etc. This system made use of graphics and sound but also included lengthy textual explanations. As with the shape recognition system, there was an emphasis on the use of colour. Ease of navigation was also a major consideration.

Undergraduate Studies in Computer Science

This system allows students to find out about the staff and the papers they teach in a Computer Science department. Photographs of staff members were included. When browsing through the system, users were able to move from a staff page to obtain information about papers taught by the staff member. Contextual information about the location of the building where the Computer Science staff were housed was also provided. The opening screen of the system showed a picture of the university grounds. Other pictures could also be viewed.

5 Educational Issues

Although the course does not deal with issues of computer-based learning, this was the focus of the assignment and gave the students some context for the systems they produced. They were expected to choose an approach to teaching which was appropriate for the subject that was being taught and that they felt would be effective in a multi-media setting. They all propounded the philosophy of their systems during their presentations. It is interesting to compare the different approaches that the students chose for their systems and how this was reflected in the presentation styles.

The Maori language teaching system immerses the student in the subject and attempts to teach by example. As noted earlier, the system can be used without reference to English words or phrases. Maori, like various other languages such as Japanese is very much bound up in the culture of the people and so this approach seemed entirely appropriate. Maori songs, words and phrases in a commentary with accompanying visuals provided a backdrop that was both stimulating and educationally appropriate.

The road code system contains video clips produced by the students themselves which graphically illustrated both correct and incorrect procedures to be followed in various situations when driving. This could be regarded as teaching by presentation and illustration.

Like the road code tutorial, the earthquake dis aster system has an emphasis on illustration using video clips and contains other factual information in an appropriate form.

Unlike the previous systems, the shape recognition tutor includes trial and error examples for the student to consider. It takes into account the answers the student gives and does not continue until it judges s/he has fully understood all the current concepts. It could be regarded as a mastery system from this point of view.

The internet system contains a great deal of information in a text-based format, but the presentation was enhanced with appropriate animations. Material is set out in an simple to follow form and subjects can easily navigate around the system to discover what they need to know.

The undergraduate studies in Computer Science system also allowed students to learn about the department of Computer Science in a discovery mode. In some senses this was the package that was the least like a tutorial system, since it just provided information in a non-instructional form.

The underlying objective of the assignment was to determine whether or not students had assimilated a fundamental principle of HCI - that issues concerning functionality should not be divorced from interface concerns. Given the experience of developing a multimedia system, it was hoped that students would take into account the educational aims of the system as well as the multimedia features. It was not the object of the exercise, however, to see whether effective learning took place. It was expected that some variation of expert evaluation would be followed. What was of interest were the criteria that students incorporated into their checklist. Issues it was hoped would be addressed (in the light of the literature on this topic) included the following:

whether the interface reflected the educational objectives of the system;
the suitability of the media selected;
the user appeal of the systems;
the interface concerns;
evaluating the execution of the various media.

6 Results

Every student (thirteen in total) appraised all the systems developed by their colleagues. All the students provided a checklist of the criteria used for the evaluation - some were very detailed and others quite brief - from thirty items at one end of the scale to five at the other. The two students with the longest checklists evaluated whether the system fulfilled its objectives, the selection of multimedia components and the execution of the multimedia as well as detail of the interface such as the provision of feedback, ease of navigation etc. There were another three quite comprehensive taxonomies which covered many but not all of the relevant issues. Five students used Nielsen's [10, 11] guidelines for heuristic evaluation without adding to them to deal with the educational or multimedia aspects of the systems. The three students with the short checklists had incorporated rather broad categories such as ease of use, knowledge presentation, navigation, multimedia concerns and quality of knowledge which gave them reasonable but not complete cover of the relevant issues.

Expert evaluation can be carried out by anyone with appropriate skills and by more than one evaluator. In one case, two people evaluated the systems and combined their findings whilst on another occasion the student drew up the framework but did not carry out the heuristic evaluation himself. Some students scored the various items and averaged the results. This enabled systems to be ranked. Others did not attempt to provide an overall score for each system but left the findings to speak for themselves.

1. Did students check to see whether the interface reflected the educational objectives of the system?

In total, eight of the students included questions in their checklist which related to the educational nature of the system. Three of these explicitly mentioned the educational objectives of the systems under review before providing their assessment.

> *"This system is a multimedia tutor system designed to aid students in learning the Maori language. The system uses both visual and aural stimuli to teach words and concepts."*
> *"The system aims to provide information to undergraduate students."*
> *"It aims at helping children to learn a shape through playing which makes learning easy and fun."*

The eight students who considered the purpose of the system, that is its educational aspect, did not all ask the same questions. A variety of issues were covered as follows:

How does the system consider educational objectives?
Is the system suitable for intended users?
Who is the target audience?
Is the system aimed at the right audience?
Does the system have a reasonable informational content?
Is the quality of knowledge sufficient?

The evaluations included comments such as the following:

> *"Good way to teach a student with audio pronouncing the language and seeing the words on the screen."*
> *"Including some information on the properties of the different shapes and showing everyday examples of them would make learning the shapes a richer experience."*
> *"It does not really seem to be an educational system, more an informative system."*
> *"The current system does not seem to have a glossary page, A page for quick lookups and acronyms and jargon would probably be helpful."*
> *"It might have been good to have an option of telling users what the different shapes look like."*

Some of the students, however, not only evaluated the systems in accordance with their checklist but also in the light of their experience in appraising the programs. They mentioned, therefore, other important criteria in their assessments. One student centred her overall assessment around the suitability of a system for its purpose although this was not included in her criteria for evaluation. Two other students, also, mentioned educational issues such as whether the systems provided adequate content and comprehensible instructions.

> *"I had no idea what I needed to do and how the test was being processed."*

2. Did the students consider whether the mix of multimedia selected was appropriate for the stated purposes of the system ?

Only two students included in the guidelines for evaluation the need to consider whether suitable media were selected and used appropriately. One student asked the question "*Is the multimedia actually of use and not redundant?*" The other student checked that the mix of multimedia was used appropriately. This student noted not only occasions when a particular mix of media was ineffective but also when media was missing.

> *"The current system seems to rely too much on textual information. Improvements would be to make more use of video, diagrams and to provide more navigation options. These changes would give the user a more enriching learning experience."*

Many other relevant comments were made by the other students about an appropriate usage of multimedia, although they did not take the issue into account systematically.

"Of all the applications reviewed this has the most appeal due to its excellent usage of graphics and sound. The main area it could be faulted on is the large textual explanations given but these are offset by the following graphical examples."

"It uses multimedia such as sound and text making the system vivid and active."

Only one student fell into the trap of believing that a multimedia system had to incorporate all media. He would criticise a system that did not include video, for instance. No regard was paid to whether adding video would contribute to meeting the goals of the application.

3. Since educational systems have to be appealing to their users, did the students take this factor into account?

With regard to the appeal of a system, this issue was only expressly considered by four students. Related questions were as follows:

Is the system interesting and fun?
Does the user find the system visually appealing?
Has information been presented in an interesting manner?
Has the system an attractive presentation?

Comments made by these students include the following:

"Its creative design of the main menu ... and its appropriate use of the sound medium, make it enjoyable to use the system."
"There was no splash screen introduction. Whilst this may seem superfluous, good splash screens can be used to arouse a user's interest."

Three other students, however, did mention this issue. One of these was the student who did not carry out the expert evaluation himself. After watching the evaluation (according to Nielsen's guidelines as specified), he realised that the system he preferred obtained the lowest rating. He proceeded to base his overall assessment of the systems on whether they had an interesting and attractive interface. A second student also focused on the interest or lack of it in the programs. Of the Maori tutor, she said " *The welcome interface is impressive. The background and the music gives me some feeling of Maori culture.*" According to her, another system was a little bit boring.

An issue that relates to the appeal or attractiveness of a system is the appropriate use of colour. Four students included at least one item in their checklist concerning colour. Questions were as follows:

Are too few or too many colours used?
Is the colour in the system beautiful?
Does the use of colour help to make the displays clear?
Is the use of colour bad, normal, good or excellent?

One system was notable for its use of colour and several comments were made about this

"The very colourful shapes used are appropriate for the school based children as seen as being the intended users."
"The colour used in the system is beautiful."
"Good colour choice, relaxing."

This was not the only the system to make effective use of colour, however and one student observed in his conclusion that no-one made the mistake of using too many colours.

4. What typical interface factors were considered?

All of the students checked for at least one well-known interface concern such as consistency, clearly marked exits etc. Seven of them specifically included the guidelines for heuristic evaluation by Nielsen and Molich [11] or the updated version by Nielsen [10] in their checklist.

It was also expected when considering interface issues that the importance of navigation in interactive instructional systems should be recognised. It should not be just one more item in a checklist. Eleven of the 13 students took account of this issue.

"No stop, rewind or scroll bars for video."
"Gives reasonable freedom to navigate backwards and forwards."
"Not very flexible, very linear in its execution."
"It is very easy to get "lost" while navigating through the system. No "back" button provided."
"Clicking at various places in the window may move you to unexpected screens."
"With the test screens there is no title indicating this."
"Have no idea what I am supposed to do in the first screen."

Four of the students highlighted the importance of navigation. Three incorporated this into their framework as a high level criteria. A fourth not only checked how users moved around the system but whether or not the users would know where they were in the system.

5. Did the students evaluate the multimedia components of the system?

Four students evaluated the execution of the individual media. Two of these assessed the effectiveness of each component: video, sound, graphics, text etc. by rating them on a scale. The third student concentrated on text and icons. His section on text was quite detailed, checking the length of the sentence, whether it just focused on one issue, and whether there was sufficient white space around it. The fourth student checked that the multimedia was not "over the top".

"When the system explained the Maori words, text is well organised."
"I liked the use of Maori music with the splash screen."
"Liked the introduction - morphing shapes."
"Widely accepted icons are used to aid page-based navigation."
"The background music is excellent. The button clicking sounds great."
"Image excellent. When the system first starts, the animation is creative and attractive."

7 Discussion

Reflecting on the results of the assignment, it became clear that learning about multimedia evaluation took place at various points in time. Most of the systems developed by the students were stimulating to watch. As developers the students were clearly aware of the need to use appropriate media in suitable combinations [1] and of the requirement to navigate easily through the system [12]. Some of what they had learned was reflected in the checklists that they developed for evaluating the systems of others. There was a difference, however, between the criteria specified by students for evaluation and those actually used when making their overall appraisals. These sometimes took additional factors into account that had not been included in the stated checklist. The experience of evaluating the systems themselves, allowed further learning to take place. It will be the more complete list of factors that are considered in the remainder of the discussion since the experience gained from carrying out appraisals is important and should not be discounted.

Eleven students checked to see whether the interface reflected the educational objectives of the system and two of these also considered whether the mix of multimedia was appropriate for the stated purposes. All of the students considered at least one relevant interface factor (consistency, clearly marked exits, etc). Six of the students also realised the need to find out whether or not a system would appeal to users. Four students included assessment of media components in their appraisals, however none of their questions showed a deep understanding of media issues.

It was pleasing from an educational perspective that most of the students when carrying out their evaluations took account of the functionality of the system. This cannot be divorced from interface considerations as for many users the interface is the system and must deliver the appropriate functionality.

Interface issues, too, were seen as important by all of the students. Of these, 11 checked to see whether a user

could easily navigate around the program. This is an important issue in interactive multimedia systems and was recognised as such by the students. Eight of the students carried out a reasonably comprehensive evaluation of traditional interface concerns but for five it was rather rudimentary. This was surprising given the emphasis on the heuristic evaluation in the undergraduate and post-graduate courses.

Overall there were only two students whose evaluation was limited to just those interface issues covered by Nielsen [10, 11]. This meant that they excluded educational considerations, the appeal of the interface, an evaluation of the individual media and whether or not they were used in appropriate combinations.

A major weakness in the student evaluations' overall was the failure to consider whether the mix of multimedia selected was appropriate for the purpose of the system. Whilst the students did consider educational issues at a high level, they found it difficult to move to a detailed perspective, that is were suitable media selected and combined? This may involve greater knowledge of the potentialities and problems of the individual media than the students possessed. They tended, therefore, to have an overall impression of a system. This was reflected again in the failure of two thirds of the students to evaluate the exe cution of each media component.

Around 50% of the students did not take appeal/interest and fun sufficiently into account. This can possibly be attributed to the fact that they were not the intended users of the systems. If they had been drawing up a list of questions for users to answer they may have incorporated this. Nonetheless, it was an important omission as multimedia systems set out to interest and hold the attention of their users.

As the above discussion shows, students were particularly weak in considering what was to them the new area of multimedia. They did not appear to have the knowledge or experience to determine how to evaluate the media. They were given some exposure to these issues in lectures but do not appear to have followed them up. Whilst no one student came up with a complete checklist for evaluating multimedia systems, amalgamating the items in their checklists enables a comprehensive framework to be developed. See Appendix 1 for the main features of this. In future it may be preferable to provide students who have built a multimedia system with some scaffolding to help with the evaluation phase. Scaffolding [3] refers to supports that can be provided by a teacher to students. The main headings in the taxonomy outlined in the Appendix could be provided. The students could then be asked to develop appropriate questions for each area.

8 Conclusions

The students learned a great deal by building multimedia software and evaluating the systems of others. This was reflected in the perceptive comments of the students made in their written assignments. It was not always reflected, however, in the frameworks for evaluation that they developed, only two of which were comprehensive. Certain areas were handled well by the students, for example checking that each system was suitable for its purpose and the importance of navigation. Two significant issues, though, were only identified by a minority of the students – the need to choose appropriate media and to determine how well they had been produced. It appears that because the area of multimedia was new to the students, they needed more scaffolding in place to be able to learn from their own experiences. Instead of developing an evaluation framework from scratch, some initial information can be given to students in future that they then have to flesh out.

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Appendix 1

1. Does the system meet its objectives?
   - Who is the target audience?
   - Is the system suitable for the target audience?
   - Does the system include (in the case of educational systems) sufficient content?

2. Has an appropriate mix of multimedia been selected?
   - Have sound and text been used effectively together?
   - Have sound and graphics been used together effectively?

3. Will the program appeal to users?
   - Is the system fun?
   - Will the user find the system visually appealing?
   - Has the system a features that will pall over time e.g. an unusual sound or joke?
   - Has colour been used in an appropriate fashion?

4. Has the interface been properly constructed?
   - Is the interface consistent ?
   - Is help available when necessary?
   - Can users easily navigate around the system?
   - How does the user navigate around the system?
   - How does the user know where s/he is?
   - Is progression through the program logical?
   - Can the user start and stop as required?

5. Have the individual media been well-executed?
   - Is the text /graphics,/sound etc well produced?
   - Are the sections of text too long/too short?
   - Will the text be understood by the target audience?
   - Has text been expressed using elaboration, representation or abstraction?

Learner Control in Technology-mediated Learning within a Constructivist Model

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This paper explores current strategies on learner control within a technology-mediated learning environment, with a special emphasis on constructivism as the underlying learning theory. An adaptive learning model, based on constructivism is presented. The model addresses the issues of learner control and its implementation within a technology-mediated learning environment. The model's major components: Learner module, Designers module, User Control Manager module, Cyber Classroom module and the Analyser module are outlined and analysed. The aim of the model is to offer an adaptive learning system that caters for different types of learners and learning styles, with an especial emphasis on learner control. The model empowers the learners and provides them with the means for constructing and re-constructing knowledge at their own pace within a constructivist framework that is learner centred and flexible. We propose a system that is dynamic and merges the capacity to deliver educational material with the ability to analyse learners performance, based on navigational patterns and results, and system performance in order to either advise and guide the learner or to modify learning materials or their presentation.

Keywords: **Learner Control, Technology-mediated Learning, Constructivism, Technology-mediated Adaptive Learning Model.**

1 Introduction

Technology has impacted greatly on education. Since the introduction of technology, new delivery methods, as well as new challenges, have emerged. One of the most important delivery methods introduced has been flexible delivery or flexible learning as it is now preferably called. Flexible learning is learning that can be achieved at your own pace and independently of time and place. Several technology-mediated approaches, for example, Web Based Instruction (WBI) and Competency Based Instruction (CBI), have been used to provide the flexibility required to deliver flexible learning.

Technology-mediated learning is versatile. It can be used as the only means to deliver education or as an aid to traditional up-front teaching. Although technology has been embraced by education, there are areas of concern over its use, or more precisely, over its misuse. Areas of concern include: access to the medium, measurement of students learning, testing the validity of the Internet as an instructional medium and the cost of producing technology-based learning materials (Rickard, 1999; Eckert *et al.*, 1997). Selwyn (1996) points out that the Internet can become a trap for both teachers and students as it can go from the '*tool to the toy*' in education if its use is not properly guided and monitored. Phillips (1980) also expresses concern about the quality of on-line materials on the Internet. In spite of these issues the proliferation of courses designed and developed for a technology-mediated environment continues to increase.

This paper explores current trends on technology-mediated learning environments with an especial emphasis on learner control. The paper also proposes an adaptive learning model based on constructivism. The model addresses the issue of learner control and its implementation within a technology-mediated learning environment.

2 Technology and learning control

A technology-mediated environment offers the learner a number of choices and alternatives that were inconceivable in a traditional educational setting. Traditional education, both on-campus and distance learning, is highly structured, teacher centred, mostly one-way communication and directed to passive learners. In contrast, technology-mediated learning, within a constructivist approach, can be learner centred, unstructured to suit the learner's individual learning needs and context-based. It also allows the learner to take control of the learning process, promotes social discourse and collaboration and contributes to the personal growth of the learner.

2.1 Learner Control in Technology-mediated Learning

The definition of *learner control* often appears to be elusive. In its broadest sense, learner control refers to the level of self-determination that the learner has in making decisions about his/her learning (Doherty, 1998). Learner control is often being addressed in combination with other factors. For example, learner control and attitude towards the technology-based system used (Ivanoff and Clarke, 1996; Mitra, 1997) and learner control and epistemic beliefs (Jacobson, *et al.,* 1996). Learner control, within the scope of this paper, refers to the degree of autonomy that learners have in organising, pacing, sequencing and using the available learning resources. That is, the ability and power of adapting the technology-mediated environment to suit their individual specific learning needs. Control over their learning direction and pace is made possible by the many alternatives and choices that a technology-mediated learning system offers the learner (Bagui, 1998). The level of control that the learner needs to exert over the learning environment is not constant over time. Learners will engage in different levels of control depending on their individual learning style (Rasmusen and Davidson-Shivers, 1998), prior knowledge of the material or related material (Fitzgerald and Semrau, 1998), attitude towards information technology (Ivanoff and Clarke, 1996; Mitra, 1997) and past experience, initiative, intellectual and social maturity, metacognitive proficiency, and insights (Ewing *et al.,* 1998).

2.2 The role of the teacher in Technology-mediated Learning

Frank Wydra anticipated a learning environment in which the teacher's role focus changed from delivering instruction to designing the instruction (Wydra, 1980). By the hand of technology we may transform the teacher from the "*sage on stage*" to the "*guide at the side*" (Andrews, 1997). Within a technology-mediated learning environment, the educator's role, far from becoming redundant, metamorphoses into a more challenging and active one. The educator becomes the leader, designer and manager of the learning environment (Doherty, 1998). Other vital functions are initiating the learning process; supporting, encouraging and motivating the learner and mediating between the learner, the technology and the resources (*Ewing et al., 1998*).

The new role of the teacher, in technology-mediated learning, is a very demanding one. *Ewing et al.,* (1998) emphasise the great deal of effort that goes into planning and preparing technology-mediated learning materials and environments. The design and development of multimedia teaching material, especially for distance education, is a time-consuming process. For one hour of CBT software approximately 200 hours of development time are required (Kawalek, 1995). The educator's role does not stop after the planning, designing and preparation of the technology-based materials. It must also facilitate the learning, monitor learners' progress and evaluate the performance of the system, the learners' and his/her own in order to further improve the system. "*The need for the teacher does not go away*" in a technology-mediated environment with emphasis on learner control (Andrews, 1997).

3 Constructivism

The introduction of technology-mediated learning has called for a revision of learning strategies.

Constructivism is gaining momentum and has been heralded as the most appropriate learning theory for the technological classroom. Constructivism was introduced by Piaget's and Vygotsky's learning theories. Piaget's learning theory involves two cognitive stages: assimilation and accommodation (West *et al.*, 1991). During the assimilation stage the learner attempts to fit the environment with existing mental schemata. The accommodation stage is reached when the learner is confronted with a new experience, for which no schemata exists, or one exists but does not conform to the new experience. As a result, equilibrium occurs when, through an alternate process of assimilation and accommodation, the learner achieves cognitive stability. Externally in-coming experiences find a corresponding mental schemata and the learner is aware of this fact. In order to achieve high-level cognition the learner must be aware that learning has indeed occurred. Otherwise, learning will stop at the behaviourist level where it is ascertained by an external party, usually the teacher, or in the case of a technology-mediated environment by a computer program.

Vygotsky's learning theory differs from Piaget's in that he sees learning taking place within a social and cultural context. He argues that social interaction affects the way the learner sees the world. That is, it contributes to the way the learner constructs his/her schemata. Therefore, the quality of the learning will be determined by the quality of the social interactions or what Vygotsky terms *zone of proximal development* (Oliver, *et al.*, 1997).

In a learning environment the cultural and social interactions translate to interactions between teachers and peers. Within this collaborative learning environment the teacher becomes the facilitator of learning. The facilitator's role should be to design, promote and guide the learning but not to enforce it as learning is an individual process. Knowledge in this environment is socially constructed and has no absolute value but a socially agreed value.

4 The proposed learning model

The aim of the proposed model is to offer an adaptive learning system that caters for different types of learners and learning styles with an especial emphasis on learner control. The proposed model operates within a constructivist approach to learning (Ewing, *et al.*,) based on the following points:

1. **All learners are different**
2. **Learning is individual to each learner**
3. **A learner can learn at different speed levels in different situations**
4. **A learner can engage in different learning strategies simultaneously**
5. **Learners learn best with a context**
6. **Learners construct and re-construct knowledge as they seek to understand and explain their environment**

4.1 Proposed model learning variables and controls

The concepts of learner individuality and learner control are essential to constructivism. Table 1 below depicts the main variables involved in the proposed model in relation to learning control and learners' choices and options.

VARIABLES	CONTROLS	
	INSTRUCTOR	LEARNER
Learning Objectives	Overall	
Amount of information provided	Overall	
Amount of information used **Addition/removal of material**		Desirable
Material appearance and mode		Desirable
Pacing, time	(When necessary)	Desirable
Sequencing	(When necessary)	Desirable
Place, location		Desirable
Monitoring learners' individual progress	Overall	
Interaction and collaboration	Shared	Shared
Assessment	Overall	

Table 1. Control Variables and Controllers

The term ***desirable***, rather than ***overall***, is used in the learner control column because the proposed model's aim is to empower learners not to force them to take control. For example, a learner that possesses prior knowledge of a topic is more likely to exercise control over his/her learning than a novice learner is. The second is more likely to follow a linear approach to learning until he/she too acquires prior knowledge.

Learning objectives
Learning objectives within the model are explicit, clearly specified and achievable. The acquisition of non-anticipated learning objectives is possible within the system, especially, when the learner accesses more information that is required to complete a task. This is a positive feature of the model as far as the specified learning objectives have been reached.

Amount of information provided and used
The system contains all the information necessary to achieve the specified learning objectives or provides references to acquire it. However, the learner controls the amount of information that is actually used. A learner can discard a particular learning material piece in favour of another, which has been acquired from external sources, just because is easier to understand or is visually more appealing. Learners' performance can be improved by designing materials that can be adapted to satisfy different learning styles (Rasmussen and Davidson-Shivers, 1998).

Learning material appearance and mode
A genuinely adaptive technology-mediated learning system must allow learners to customise the appearance and mode of the material displayed. This may include: changing background and text colours and choosing between text, graphics, audio and video modes.

Pacing and timing
The learner has the autonomy of pacing his/her learning and scheduling his/her study time. However, in some instances this has to fit within the general time-frame allocated to the course or subject. The designer controls the general time-frame, if one exists.

Sequencing
Learning materials must be accessed in the order that most benefits the learners' learning style. The model is able to cope with the demands of linear as well as non-linear approaches to learning. Figure 1 displays an example of the progression or navigation path of a learner who prefers to be guided by the system. '*Learner 1*' uses all the material provided and in the order provided until she encounters difficulties and seeks the help of an instructor or other learners. Then, revises the previous lesson and again continues with the linear path provided. In contrast, '*Learner 2*' feels confident enough to discard material provided and adds material from external sources. Both learners achieve the corresponding learning objectives through the use of different learning strategies. Beginners often benefit from having a structured learning path (Eaton, 1996). A graphical representation or map of the entire unit or lesson must be made available to the learners to guide their navigation decisions (Barba, 1993).

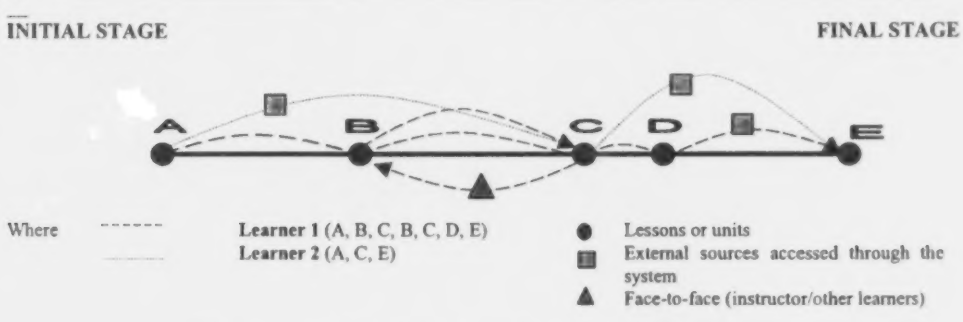


Figure 1. Learning Sequence Patterns – Linear and Non-linear

Learners must be free to use forward and backward navigation through the system as long as it does not compromise the learning itself. For example, if the completion of a task is the pre-requisite for another,

allowing the learner to move onto a task for which a pre-requisite has not been completed might result in a waste of time and unnecessary added frustration for the learner. For example, moving into algebra without knowing how to multiply.

Place and location
Technology-mediated learning offers the possibility of accessing and using learning materials at different locations. Using the proposed model, learners can now study at home, at appropriately equipped learning centres or at traditional classrooms.

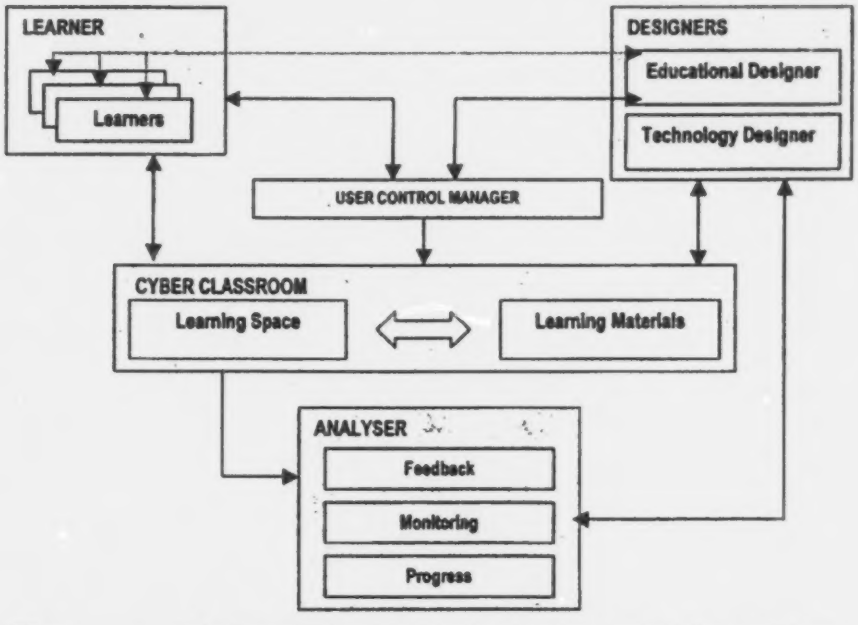
Monitoring learners' individual progress
Instructors are in control of monitoring the learners' individual progress. Based on the analysis of the learners' performance instructors can either guide or advise the learners through different strategies or modify the system.

Interaction and collaboration
The system must provide the capabilities to allow learners to interact with each other and with their instructors. This communication may occur, for example, through e-mail, and on-line forums. Physical, or face-to-face, communication is also a part of the model.

Assessment
Assessment is designed and administered by the instructor. This is to evaluate the students' learning performance and to provide feedback both to the educator and to the students.

4.2 Technology-mediated Adaptive Learning Model

The proposed model, the Technology-mediated Adaptive Learning (TAL) model, is composed of five modules: Learner module, Designers module, User Control Manager module, Cyber Classroom module and Analyser module, Figure 2.



Where ⟶ Technology-mediated communication (web browsing, down/uploading, email, forum, database updates, ...)
⟶ Physical communication

Figure 2. The Technology-mediated Adaptive Learning (TAL) Model

4.2.1 Learner Module

The learner module comprises the learner group. Learners interact with the TAL system through the Learning Space. Communication with instructors and other learners occurs within the Learning Space or physically, as indicated by the dotted line in Figure 2.

4.2.2 Designers Module

The designers' module can be composed of an educator, instructional designer, multimedia designer and technicians. This module is concerned with three main areas: the educational design, multimedia design, and computer and Internet technology. The educational designer is in charge of designing quality learning materials within a constructivist approach. This includes being aware of the subject matter as well as the pedagogical theory in use. The multimedia designer and the instructional designer help the educator to appropriately formulate the teaching materials for CBI or WBI. The technology designer provides the means to make the learning materials available to the learner group through a technology-mediated environment. Good skills and tools for multimedia authoring and technical services are required in this module, which may cause production cost issues.

4.2.3 User Control Manager Module

The User Control Manager allows the learner to customise the learning space. Through this module the learner can select the display mode to suit his/her own learning needs and preferences, for example, text, graphics, audio or video mode. Pacing and sequencing of the learning material can also be controlled from this module.

4.2.4 Cyber Classroom Module

The Cyber Classroom module is composed of two sub-modules: Learning Space and Learning Materials module. The Learning Space is where the learning is delivered. This is generally a kind of display unit, such as a personal computer or a network terminal screen. It may also include equipment for sound and video. It must be easy to interact with and be self-explanatory. Within the Learning Space the learner has the option of accessing learning materials provided by the educator, such as lecture notes, or external resources such as Internet sites or libraries

4.2.5 Analyser Module

The purpose of the analyser module is three-fold. First, it gathers statistics on the performance and progress of learners. Second, it records learners' perceptions about the learning material presented and about the overall working of the system (learner feedback). Finally, it monitors and records students' navigation patterns into a database. These will provide an indication of the learners' preferred learning styles. This information can be used to provide advice for the learner and to improve the system (Chavero *et al.*, 1998) by evaluating the existing materials and options and formulating new ones. The optimal implementation of the system will be to incorporate an Intelligence module to automatically generate and administer changes, based on the information within the database.

The TAL model is being implemented in a couple of different programming languages and database tools.

5 Reviewing learner control, constructivism and the TAL model

5.1 The TAL Model and Learner Control

The main objective of the model is to provide a technology-mediated learning system able to support learner control within a constructivist approach. The learner control variables, identified in Table 1, have been built into the model. Learning objectives, amount of information provided, monitoring of learners individual progress and assessment are overall controlled by the instructor, while the amount of information used/added/removed, material appearance and mode, pacing, timing, sequencing, place and location are potentially controlled by the learners. Interaction and collaboration can be initiated by either party as the need arises.

5.2 The TAL model and Constructivism

The underlying pedagogical theory governing the TAL model is based on constructivism, and specifically on the constructivist elements represented in the table below. The model addresses all elements, however, its concrete effectiveness will only be determined after development and implementation, in practice.

TAL Constructivist Approach Checklist	
EXPECTED CONSTRUCTIVIST ELEMENTS	**TAL MODEL**
• All learners are different	The model allows for learner differences in needs, learning styles, and skills.
• Learning is individual to each learner	Learners can customise the learning materials to suit their learning styles and needs through the User Control Module.
• A learner can learn at different speed levels in different situations	Learners can control pacing and sequencing of learning materials.
• A learner can engage in different learning strategies simultaneously	Learners can engage in linear and non-linear strategies. Also they can learn independently and/or seek collaboration.
• Learners learn best within a context.	Learning materials (provided by the TAL model) are always presented within a context.
• Learners construct and re-construct knowledge as they seek to understand and explain their environments	This feature is intended within the model but only after implementation will it be ascertained.

Table 2. TAL Constructivist Approach Checklist

6 Conclusion

This paper has addressed current educational trends on learner control within technology-mediated learning environments. The roles of the learner and the teacher have been reviewed and analysed in the light of technology-mediated environments.

The TAL model, based on constructivism, was presented, and its major functions were explained. The model includes five modules: Learner module, Designers module, User Control Manager module, Cyber Classroom module and the Analyser module. The aim of the model is to offer an adaptive learning system that caters for different types of learners and learning styles, with an especial emphasis on learner control. The model presented, empowers the learners and provides them with the means for constructing and re-constructing knowledge at their own pace within a constructivist framework that is learner centred and flexible.

From the designers point of view the model is a dynamic system that merges the capacity to deliver educational material with the ability to analyse learners performance (based on navigational patters and results) and system performance in order to either advise and guide the learner or to modify learning materials or their presentation.

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Learning algorithm design through interactive simulation

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The teaching of algorithm design is a subject of great difficulty, however, its value has not been addressed in the curriculum of computer studies in secondary schools. The aim of this paper is twofold: to describe the method and design principles of developing the Traffic Light System Simulator (TLSS) and to discuss a learning example of using TLSS. The TLSS is a learner-centred simulation tool for learning algorithm design. It provides a daily life problem in a learning environment. In solving the problem, students are encouraged to think and construct their own possible solutions. It is believed that the TLSS would inspire students to look beyond the traffic light simulation and transfer the insight to the learning of algorithmic thinking.

Keywords: **programming, algorithm, simulation, learner-centred**

1 Introduction

"Algorithmics is the spirit of computing" advocated by Harel [4]. Computer programming mainly consists of three activities - problems identification, analysis; algorithm design to tackle problems; and algorithm representation in a computer coded language [16]. Algorithm is usually defined as a method, procedure, recipe or step-by-step process for doing a job, or a finite sequence of unambiguous, executable steps that will ultimately terminate if followed, in which "unambiguous" means at each step the action to be performed next must be uniquely determined by the instruction and the data available at that time. Yet algorithm design is usually more challenging and problems-bounded as it involves solving continuous problems during execution [16]. To design an algorithm is to find a step-by-step procedure for locating a clue for errors [5]. This design activity entails an exceedingly diverse activity and involves complex cognitive processes. Difficulties in discovering algorithms are prevalent in the learning of computer programming.

The teaching of algorithm design is a subject of great difficulty, its value, however, has not been addressed in the curriculum of computer studies in secondary schools. Algorithm design has been revealed as an activity that demands abstraction, analysis, and synthesis abilities from students [3]. Therefore, the learning of algorithm design contributes not only to the teaching of computer programming, but also the cognitive development of students [17]. This paper attempts to address the importance of algorithm design in computer programming by examining the development of the Traffic Light System Simulator (TLSS), a learner-centred simulation program for learning algorithm design.

The TLSS, comprising simulation, animation, sound, text, graphics and video, aims to stimulate learners' interaction and initiative by simulating the actual algorithm design activities in learning process. As the word "interaction" indicates in its compounded use with multimedia. Interactive multimedia enables learners' communications, exchanges and involvement. Effective use of interactive multimedia enhances learning motivation and retention. Multimedia also provides an authentic environment which is relevant to daily life. The aim of this paper is twofold: to describe the method and design principles of the TLSS development and to discuss a learning example of using TLSS.

2 The Development of TLSS

In the development of the TLSS, the prototyping paradigm was adopted. Prototyping is a process allowing the developer to create a model of software that will be completed in the future. Like all approaches in software development, prototyping begins with requirements gathering [12]. However, Marques i Gralles [8] opines that the "development of an educational program always begins with an initial idea which seems to have the potential for enhancing particular teaching and learning processes". In other words, the development of TLSS, backed by Marques i Gralles' initial concept, has been supported by basic principles. The present model's principles are to apply the learner-centred approach as well as to nest with the understanding of teaching and learning algorithm design in secondary schools [18]. Grounded theory [3], which is a methodology for the systematic generation of conceptual models from qualitative data, was used to collect and analyse information from the interviews of teachers and students [20] during requirements analysis.

The label "grounded theory" means "the discovery of theory from data" [3]. Grounded theory is an approach of the handling of qualitative data and of the formulation of theoretical propositions in social sciences, and this methodology has been used successfully for conceptual analysis in a number of information system development projects [11].

Strauss [15] presents a "concept-indicator model" to direct the conceptual coding of a set of empirical indicators. It is a possible operation of concept formation from qualitative data. Indicators are labels for actual data, such as behavioral actions and events, observed or described in documents and in the words of interviewees or informants. By constant comparison of indicators to indicators and their related data or documents, the researcher is forced into confronting differences, and degrees of consistency of meaning among indicators. This generates an underlying uniformity, which in turn results in coded categories, coded relations, definitions and properties of categories and relations, and theoretical concepts.

In order to develop a system "grounded" from the teaching and learning of teachers and students, twelve teachers and ten students from various schools were interviewed. The following issues were addressed in the interviews: (1) to identify the difficulties of teaching and learning of algorithm design in secondary schools, (2) to examine the needs, skills, and interests of students in the learning of algorithm design, and (3) to identify a series of problems conducive for learners' further exploration and motivation. Data were analysed using the constant comparative method in grounded theory.

The following is a brief summary of some major findings supporting the TLSS development: (1) algorithm design is too abstract to some students, (2) students are lack of logical thinking skills, (3) some teachers think that learning algorithm design is very important, (4) some teachers think that algorithm design can be learned naturally, (5) students' existing mental model is an important factor of learning algorithm design, (6) most students cannot decompose problem into sub-problems, (7) there is a lack of teaching material in algorithm design, and (8) the curriculum is not related to daily life.

The results also reveal that teachers use either teacher-dominated method or subject-centred method. Teachers with teacher-dominated method "are serving the immediate needs of the dependent, authority centred, linear thinking students" [9]. Teachers in this case direct students' learning through a straightforward lecture of textbook and presentation. Teachers who teach with subject-centred method "are providing more information and use a greater variety of presentation method" [9]. The responsibility for learning is on students, while the teacher primarily provides opportunities for learning to take place. Most teachers adopt this subject-centred method. They teach with metaphors, examples, pictures or games. Apart from textbooks, they also prepare notes, laboratory sheets, and supplementary exercises as teaching materials.

The discovery method of instruction for teaching computer programming is one of the major focuses in educational computing research [14], and discovery learning occurs when a learner is motivated to act and allowed to formulate and test questions or answers [7]. A number of studies suggest to connect computer programming with logic, truth tables, switching circuits, gating symbols, flow charts, pseudocode and visual simulation enhance the teaching and learning of computer programming in secondary schools [1]. Other studies indicate that algorithm animation seems to be a useful tool for teaching algorithm [6].

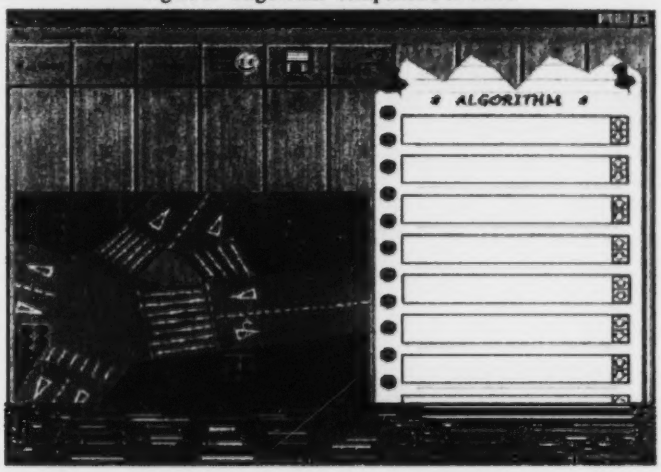
Further to these observations, this paper focuses on the learner-centred approach which facilitates active, multi-functional, inspirational, and situated educational experiences. The basic principles of learner-centred

approach can be summarised as: (1) problem-driven rather than structured analysis of the curriculum content; (2) attending to learners' needs, skills and interests; and (3) learning on a constructivist approach.

3 The TLSS Simulation

The TLSS embraces two distinct features. First, the system provides students with an authentic multimedia context that will motivate students to learn and explore [19]. The system allows continuous feedback and challenge to stimulate students to decompose the challenge, thus keeping students continue learning activities [13]. Second, students might benefit from actively constructing the algorithm than passively watching the algorithm. The system supplies a visualised simulation and an animated environment which students are actively immerse in creating, exploring, testing, and understanding their implemented algorithms.

Figure 1: "Algorithm" components of TLSS



The TLSS provides a dynamic model of a traffic light system with simulated roads, traffic lights, vehicles, pedestrians and various traffic situations. It allows students to present and test their algorithm of controlling a traffic light system in animation. The system also represents students' algorithm in Pascal programming language to reinforce programming language learning.

The TLSS consists of two major components namely, "algorithm" and "simulation". In the "algorithm" component, users are asked to design an algorithm using "while", "for" and "if-then" to control five sets of traffic lights at a junction (Figure 1). Students are expected to begin by simple guided situations on resolving two traffic lights. Each "if-then" will be contained in statement 1 and 2 of a set of algorithm design. Implanting "if-then" statements may be relatively simple and direct for most students. Other components, "for" and "while", targeted at coupling the algorithm with variables and validity, complicates the activity. From the outset of the compilation, students will be given no explanation of the set, "if-then", "for/while", but be guided on a step-by-step traffic light simulated situations to generate in them understanding of the syntax. Students will use each set of algorithm, represented as statements ensuring the smooth running of traffic lights, to assign the colour of traffic lights and its time span. Incorrect input of algorithm or a change of the idea can be rectified by pushing the "undo" button. The "save" button enables students to retain their exercises. After compiling the algorithm, students can proceed to the "simulation" component by pushing the simulated button for execution of their design. Evolved will be an animated environment. Since the aim of the designed algorithm is to ensure the safety of pedestrians and vehicles, correctly compiled algorithm yields smooth running of traffic while incorrect algorithm gives rise to accidents. Accidents are categorised into car crash and car bumping into pedestrians. Figure 2 is a graphical presentation of a car accident in the simulation.

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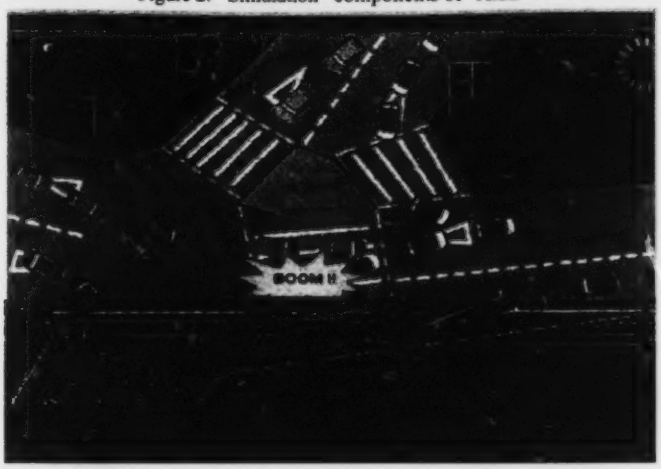
Figure 2: "Simulation" components of TLSS



If an accident occurs, users may return to the "algorithm" component to re-compile another possible algorithm and test it again. The activity allows students unlimited trials of designs and implementation. Because solutions to every situations are totally dependent on the success of the algorithm design, students' problems solving, engagement in critical thinking to reach for the success stage are crusts of the TLSS.

4 Shirley: A Learning Example

A preliminary version of the TLSS has been developed, and a group of secondary 5 students (Grade 11) with average academic ability were asked to use the TLSS for learning algorithm design and computer programming. The process of using the TLSS was observed. Because of the volume of data generated, the case of only one student, Shirley, was reported and discussed in this paper.

A sequential activity comprising a series of exercises to guide students to the final operation of all five lights is assigned (see Appendix). Each student, engrossing in the learner-centred approach, will freely discover problems and solutions on their own. Also, as featured in the approach, questions will dominate the exercise so that students can actively engross in the revelation of questions. Students are encouraged to try out patterns so as to simulate the "debugging" process of programming environment. Emphasis of the exercise will not only be the success of compilation, but on the process of compilation. The process of compiling a simulated TLSS demonstrates ways of how students can plan, debug and execute a computer programme.

Shirley, who has completed one-year programming learning practice in her secondary 4 (Grade 10) studies, started the activity by following the assignment instruction. She operated the TLSS and set the simulation off by pushing the button at the very first instance. By observing the simulated junction, Shirley tried to locate directions for the movement of cars and the operating sequence of traffic lights but of no avail. Shirley found that all traffic lights, cars and pedestrians were not working and in stand-by mode. Simulation could not be executed because algorithm was not compiled.

Having finished observation, Shirley returned to the menu and tried to familiarise herself with the available syntax of the simulation. She tried put the "If..Then" onto one of the boxes and observed the pattern of its appearance. The representation of "If..Then" as conditions to be fulfilled was acknowledged. Double-clicking the "statement 1" box, Shirley realised it was the first condition for the first part of the algorithm and the "statement 2" box was ignored. Returning to the assignment instruction, Shirley began to work on how she could survive for 20 seconds if lights 1 and 2 were simultaneously working. Without a second thought, Shirley inserted "red" and "20 seconds" for light 1 and the same for light 2. Two "If..Then" statements appeared after hitting the "OK" button. A simulated environment was followed where all pedestrians crossed the road at ease. Some pedestrians were standing on the traffic island. Shirley considered that it was due to some pedestrians were heading to light 3 area so they kept waiting on the island. The assignment question on the difference of the situation between the reality and the simulated

environment also reinforced Shirley's belief that some pedestrians were on different directions. Shirley failed to recognise the time of traffic light was determinant in affecting pedestrians' continuation of crossing the road. That misunderstanding gave rise to recurrent traffic accidents in other activities which required much longer time.

Having triumphed on the first part of the exercise, Shirley tried to make a car crash as required. For convenience, Shirley followed instructions strictly. She produced "light 2" as "red" for "20 seconds" and "light 5", "red", "20 seconds". A first car crash was experienced. It was too quick a crash and Shirley missed out the sequence, details and picture. Shirley could not answer the first question of how long it took for the first collision. Shirley decided to study and read carefully questions provided by instructions before finding out solutions. By returning again two times to the simulation, Shirley concluded that the crash took place after 8 seconds of execution. In order to remove the accident, Shirley had to find out a workable algorithm. Shirley tried to visualise the traffic pattern in her mind but was not successful. She then realised it was because the most important element of vehicles direction was not recorded. Pens and paper were ready before Shirley returned to the simulation again. She then looked for patterns of the traffic and pictured it onto the paper. She devised that light 2 should stay red long enough to allow light 5 cars to run. Although unsure about the result, she kept light 5 as red for 20 seconds and light 2, red, 40 seconds. The result was successful and Shirley proceeded to the third part of the exercise.

The third activity requested Shirley to run the car more than once. Suggestions on using "For" button was put forward. On devising "for i = 1 to n", Shirley did not understand the function of "n". No hints were given. She did not know where to put the "for" trunk at the infant stage. After several unsuccessful hits of trying to make the equation (e.g. "i" equals "10" and "n" equals "9"), Shirley took an hour break. Shirley returned and read carefully the instruction again. She decided to insert "for i = 1 to 5" and retained the previous lights 2 and 5. A first success was experienced. She concluded that "if" functioned as an executable command while "for" predicted the number of execution of the "if" command.

The fourth activity demanded Shirley to keep cars running forever. Shirley did not understand what was meant by the "for-loop" inside the "while-loop" as delineated in the activity. She tried to put the "If..Then" statements first, and then the "while-loop", the "for-loop". Consecutive errors led Shirley back to study questions carefully again. She devised the sequence of the "for-loop", the "while-loop" and the "If..Then" statements. Working out the sequence, Shirley realised that the "while" statement should always remain "True" because it kept the "If..Then" to continue for "n" times. The "If" just started the programme and "while" was a continuation command.

The fifth activity asked why car accidents occurred. The activity required Light 3 as red for 10 seconds while light 4, green 14 seconds. An alternative could be light 5 as green for 16 seconds. Shirley selected the first combination (light 3 as red for 10 seconds and light 4 as green 15 seconds) but a car accident occurred. After trying out a couple of combinations, Shirley shifted to the diagram she drew before. She worked out the flow of cars, wrote down seconds next to each light. She went back to four previous activities to devise solutions. She attended to her negligence of the importance of time element in activity 1. She finally could not contribute colours and time to lights as she could not work out the transition time of lights passing through red to green. Shirley believed there should be intermission for red-yellow and yellow lights. She recorded every combination and observed its execution. Shirley then tried to perform a monitor system by checking the time for accidents taking place like the guidance referred by activity 2. After almost 20 combinations, Shirley referred back to the question and decided to remove the "for-loop" and the "while-loop". No traffic accident occurred because there was no repetition of car flow. Shirley, however, was not satisfied with the result because reality traffic required continuous flow of cars. She tried to learn from experience in activity 2 that one light's stopping time should be longer than the other's flowing time. After almost 30 trial and errors, Shirley reached the conclusion that emphasis should be on the transition lights. Finally, Shirley gave up algorithms without reaching successful traits. The last activity requested the smooth running of cars by operating all traffic lights. Shirley did not proceed to this stage and the assignment was handed in.

5 Discussion

In the observation, we found that students using the TLSS were encouraged to participate in the thinking process of designing algorithm, such as imaging a goal, formulating a goal, inventing a product, finding alternatives, choosing the solution, generating more alternatives, making choice and evaluating choice,

which are essential elements in algorithm design [5]. In contrast with the teacher-dominated and subject-centred method, the learner-centred approach is based on the idea that "people learn best when engrossed in the topic, motivated to seek out new knowledge and skills because they need them in order to solve the problem at hand" [10]. In learning with the TLSS, students are involved in active exploration, problems solving and construction rather than passive teacher-directed lecturing. Such learner-centred simulation tool also generates in learners a long-term pursuit of examining the subject which leads to lifelong learning. Further exploration enhances creativity and critical thinking. However, some students, in particular the case of Shirley, revealed that teacher's guidance is also crucial to make such active learning successful.

The design of the TLSS is based on the learner-centred principles as well as grounded from the experiences of teachers and students. The primary goal of the TLSS is to provide a daily life problem in a simulation environment. In solving the problem, students are encouraged to think and construct their own possible solutions. Simulation, by definition, is not real. Most simulations are artificial systems that can in no way come close to the real situation in complexity and variety. In TLSS, the operation of the traffic lights is certainly different from real life. Thus, students must always be alert for the limitation of simulation. It is believed that the TLSS would inspire students to look beyond the traffic light simulation and transfer the insight to the learning of algorithmic thinking.

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Appendix: Sample Activities

How can you survive for 20 second?

- **Objective:** By the end of the activity, students should be able to use "IF ..Then" statement by using trail and error approach. Use basic problem solving skills. The activity allows the students to explore the implementation of the "If..Then" statement.
- **Activity:** In this simulation, students only use "IF-THEN" statement to control the traffic flow. (Hint: Ignoring Lights 3 to 5 and congests for route 3 to 5, control Light 1 and 2 only. Observe the pedestrians' flow).
- **Questions for Discussion:** Why there are some pedestrians standing on the traffic island? Is there any difference between the reality and the simulation?

How can we make the car running more than once?

- **Objective:** By the end of the activity, students should be able to get more familiar with the characteristics and function of the "for" button.
- **Activity:** Students should first use "for i= 1 to n", where n is any chosen number. We should predict what would happen before we run the game. No instruction will be given to students so students can make the simulation by their own. For instance, how many times of car flow occur if we set for i = 1 to 5 and put in one condition such as controlling light 1 & 2 as we tried before, inside the loop?
- **Questions for Discussion:** What is the function of the "if" statement in programming? What is the benefit of using this button?

How can we make the car running continuously?

- **Objective:** By the end of the activity, students should be able to get more familiar with the characteristics and function of the "while" button.
- **Activity:** Students are asked to control the car flow so that the car flow can run continuously. We can use the "while" statement to implement this task. "While" it is true, then do the following statement. Students are suggested to predict the effect of putting the "for-loop" inside the "while-loop" and the vice versa. They are asked to explain these effects.
- **Questions for Discussion:** What is the function of the "while" statement in programming? What are the differences between "if" and "while"?

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Making Exploration History Interactive for Web-based Learning

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The main problem addressed in this paper is how to help learners reflect on knowledge that they have constructed in exploring existing hypermedia/hypertext based learning resources on the Web. Our approach to this problem is to provide each learner with a kind of reflection support proper to his/her exploration process. In this paper, we describe an interactive history that encourages learners to annotate their exploration history with the reasons why they have explored, which reasons have a great influence on knowledge construction in hyperspace. It also generates a knowledge map, which spatially represents the semantic relationships among the WWW pages visited by the learners. This paper also describes a preliminary analysis and evaluation with the interactive history system. The results indicate that the system facilitates a rethink on exploration processes, and that the system produces good effects on learning such as integrating the contents of some nodes in more complicated hyperspace.

Keywords: Exploratory Learning, Hyperspace, Reflection, Interactive History

1 Introduction

Hypermedia/hypertexts generally provide learners with a hyperspace within which they can explore the domain concepts/knowledge in a self-directed way [3], [7]. The exploration often involves making cognitive efforts at constructing the knowledge from the contents that have been explored [12]. These cognitive efforts would enhance learning [2], [6]. However, learners often fail in knowledge construction since what and why they have explored so far become hazy as the exploration progresses. To what extent the learning has been carried out also becomes unclear [10], [12].

A possible resolution of this problem is to encourage learners to reflect on what they have constructed during exploration in hyperspace [11], [12]. The reflection also involves rethinking the exploration process that they have carried out since it has a great influence on their knowledge construction. In particular, exploration purposes, which mean the reasons why the learners have searched for the next node in hyperspace, play a crucial role in knowledge construction [8], [9]. For instance, a learner may search for the meaning of an unknown term to supplement what is learned at the current node or look for elaboration of the description given at the current node. Each exploration purpose would provide its own way to shape the knowledge structure. The reflection support accordingly needs to adapt to their exploration activities and the knowledge structure being constructed by the learners.

In this paper, we discuss a proper reflection support with a careful consideration of exploration process in hyperspace. This paper also describes an interactive history for learning with hypermedia/hypertext based learning resources on the Web. The interactive history system enables learners to annotate their exploration history with exploration purposes that have arisen during exploration. It also transforms the annotated exploration history into a visual representation called knowledge map. It spatially shows the semantic relationships among the WWW pages that the learners have visited [8]. Using the interactive history system, the learners can view and reorganize the exploration history to rethink their exploration process that they have carried out so far. They can also view the knowledge map to reflect on what they have constructed in hyperspace.

This paper also describes a preliminary evaluation of utility and effectiveness of the interactive history system. The results indicate that the system facilitates a rethink on exploration processes, and that the system facilitates learning such as integrating the contents of some pages in more complicated hyperspace.

Before discussing the interactive history, let us first consider exploration process in hyperspace.

2 Exploratory Learning

In hyperspace, learners can explore in a self-directed way from one node to others by following the links among the nodes. The exploration often involves making cognitive efforts at constructing the knowledge structure from the contents that have been explored. In order to shape a well-balanced knowledge structure, it is necessary for the learners to recall what and why they have explored so far, and to properly direct the subsequent exploration [10], [12], [13]. However, these efforts may cause cognitive overload [6].

In this paper, we consider learners who attempt to learn domain concepts and knowledge in a constructive way. Some learners may not make the cognitive efforts of knowledge construction. In this case, they may only browse or surf in hyperspace. Supporting such browsing or surfing is out of our scope.

Table 1. Exploration Purposes and Visual Representation.

Exploration Purposes	Visual Representation
Supplement	Inclusion
Elaborate	Set or Part-of tree
Compare	Bidirection arrow
Justify	Vertical arrow
Rethink	Node superposition
Apply	Arrow

Starting node Terminal node

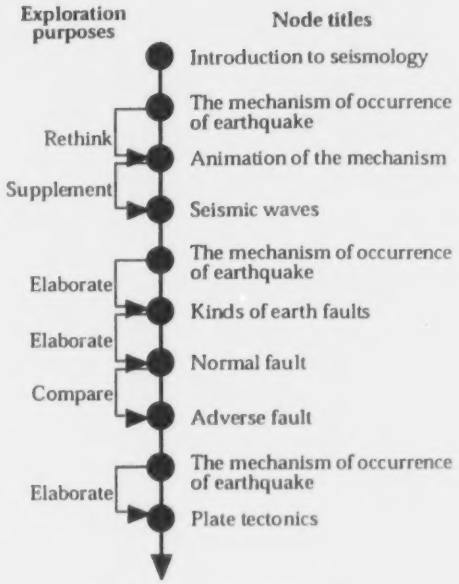

Figure 1. An Exploration History.

2.1 Primary Exploration Process

Learners generally start exploring hyperspace with a learning purpose. The movement between the various nodes is often driven by a local purpose called exploration purpose to search for the node that fulfills it. Such exploration purpose is also regarded as a sub purpose of the learning purpose. We refer to the process of fulfilling an exploration purpose as primary exploration process. This is represented as a link from the starting node where the exploration purpose arises to the terminal node where it is fulfilled.

An exploration purpose may have several terminal nodes with one starting node. Exploration purpose, represented as verb, signifies how to develop or improve the domain concepts and knowledge learned at the starting node. We currently classify exploration purposes as shown in Table 1, which are not investigated exhaustively.

An exploration purpose arising from visiting a node is not always fulfilled in the immediately following node. In such case, learners need to retain the purpose until they find the appropriate terminal node/s. While searching for the fulfillment of the retained purpose, it is possible for other exploration purposes to arise. The need to retain several exploration purposes concurrently makes the knowledge construction more difficult to achieve.

The exploration process can be modeled as a number of primary exploration processes. Let us give an example where a learner uses a hyperdocument on a WWW server with the learning purpose of understanding the occurrence of earthquake. In this example, he/she explores a number of nodes (WWW documents) with various exploration purposes. Figure 1 gives the exploration history, which shows the sequence of the nodes visited and primary exploration processes. For example, he/she visited the node *Animation of the mechanism* in order to rethink the description in the node *The mechanism of occurrence of earthquake*. He/she then visited the node *Seismic wave* since he/she did not know the meaning of the term used in the previous node.

2.2 Knowledge Structure

Exploring hyperspace in a self-directed way, learners make semantic relationships among the domain concepts and knowledge explored to construct a knowledge structure [12]. In hypermedia/hypertext systems with concept maps representing domain concepts to be learned, learners can derive such semantic relationships from the maps. Most existing web-based learning resources, on the other hand, do not specify the semantic relationships. In this case, learners need to explore WWW pages and to identify the semantic relationships by themselves for the knowledge construction.

The knowledge structure constructed is shaped according to learners' exploration process, especially the exploration purposes. Each exploration purpose provides its own way to make relationships among the domain concepts and knowledge explored and to shape the knowledge structure [8].

2.3 Reflection

Knowledge construction in hyperspace requires learners to reflect on their exploration process. Some work on analysis of exploration process in hyperspace has also shown that revisiting nodes to rethink the contents explored often take place [11], [13].

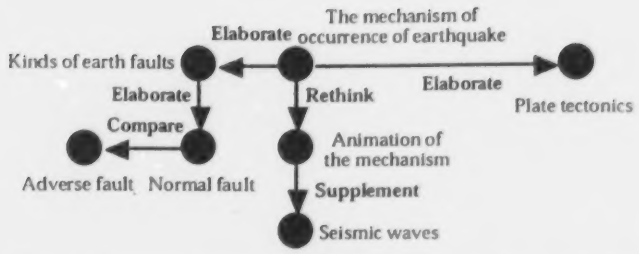

Figure 2. A Semantic Network Composing Primary Exploration Processes.

In reflection, it is important for learners to rethink not only the nodes visited but also the reasons why they have visited since these reasons have a great influence on how to shape a knowledge structure. In other words, they should pay attention to primary exploration processes included in the whole exploration process.

3 Interactive History

Let us now discuss what kind of reflection support is indicated by the above consideration.

3.1 Problems

There are the following important problems to be addressed towards a proper reflection support. The first problem is how to help learners retain the primary exploration processes that they have carried out. The retention may cause cognitive overload on exploration. It is also hard for computer to infer their exploration purposes, which arise in the learners' mind. These suggest that learners should be encouraged to note down the exploration purposes, starting nodes, and terminal nodes that compose the primary exploration processes.

The second problem is how to assist learners in reconstructing their exploration process. In reflecting on their exploration process, they would not only look at it but also reconstruct it such as modifying/deleting the primary exploration processes and adding new primary exploration processes. It is accordingly necessary to provide learners with a space where they can reconstruct their exploration process after exploring hyperspace.

The third problem is how to facilitate learners' reflection on a knowledge structure constructed. One way to resolve this is to spatially show semantic relationships between nodes explored. We represent a semantic network that comprises a number of primary exploration processes. Figure 2 shows a semantic network comprising the primary exploration processes shown in Figure 1. The semantic network does not obviously represent the contents included in the explored nodes, which may be summarized by the node titles. However, this summarized information would be substantially fruitful for learners to reflect on what they have learned.

In order to resolve the above problems, we have developed an interactive history that helps learners reflect on their exploration process and knowledge structure by means of an exploration history annotated with primary exploration processes. Let us next demonstrate the interactive history.

3.2 Overview

The interactive history system first displays an exploration history, which includes the nodes sequenced in order of time learners visited. In order to help learners note down primary exploration processes during exploration, the system provides them with a list of exploration purposes, and requires them to select one from the list when an exploration purpose arises. The learners are also asked when they find the terminal nodes. The interactive history system annotates the exploration history with the information noted down. The annotated history enables the learners to retain their primary exploration processes.

The learners are also allowed to directly manipulate the annotated exploration history to modify/delete the primary exploration processes and to add new primary exploration processes after exploring hyperspace. Such direct manipulation allows them to reconstruct their exploration process without revisiting hyperspace.

Although the annotated exploration history is represented as semantic network shown in Figure 2, it may be difficult to understand. It is accordingly transformed into a visual representation called knowledge map by means of visualization scheme that describes the correspondence of an exploration purpose to a visual representation.

3.3 Annotated Exploration History

In the interactive history system, learners can use a user interface as shown in Figure 3. They can also explore a hyperdocument on a WWW server with one learning purpose in the left window. When they want to set up an exploration purpose in visiting a node, they are required to click one corresponding to the purpose in the *Exploration Purpose Input* section of the right window. The clicked purpose is added to the *Exploration Purpose List* section. The node visited currently is also recorded as the starting node of the exploration purpose.

The learners can also add the object of the verb describing the exploration purpose. It means what to develop/

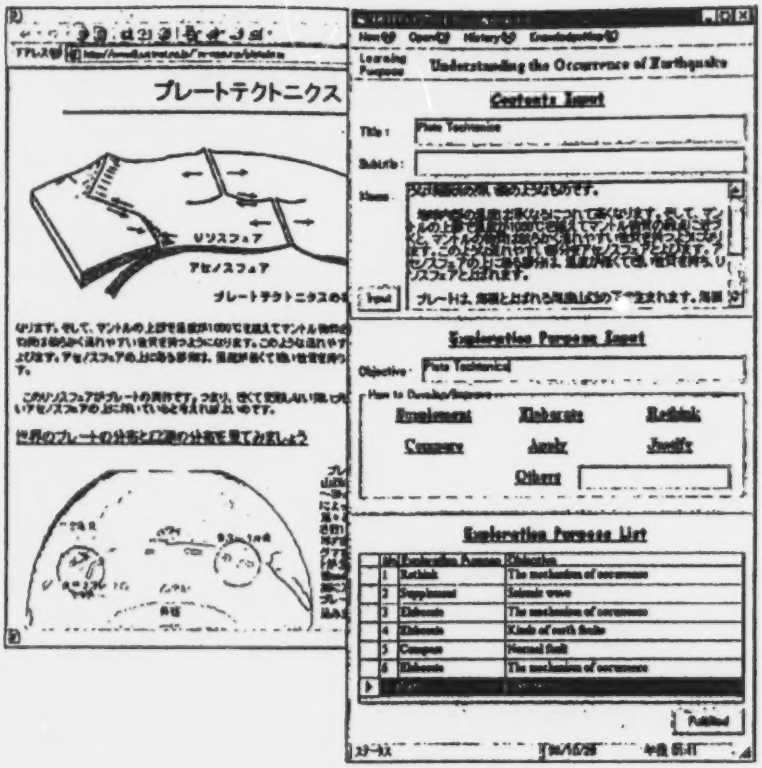

Figure 3. User Interface of Interactive History.

improve in the current node whereas the exploration purpose specifies how to develop/improve. When the learners do not add this object, the system adds the title of the current node, which is the title tag in the HTML file.

When the learners find a terminal node of the exploration purpose, they are required to mouse-select the exploration purpose in the *Exploration Purpose List* section, and to push the *fulfilled* button. The node visited currently is then recorded as the terminal node of the exploration purpose.

The system also provides another support for helping learners store part of the contents of the node visited currently with Cut&Paste function in the *Content Input* section although they may not always need this support. In hyperdocuments on WWW, in addition, the title tags of the nodes do not always represent the contents of the nodes. If the learners want to change the node titles, they can input new titles in the *Content Input* section, which new titles should represent the contents the learners explored in the nodes. The pasted information and the changed node titles are also used in the annotated exploration history.

Using the information inputted from the learners, the system generates the annotated exploration history as shown in Figure 4 so that the primary exploration processes can be viewed clearly. In the annotated history, the nodes learners visited are sequenced in order of time. Each node has the node title. The starting node of each purpose is linked with the corresponding terminal node/s. There may be some primary exploration processes without terminal nodes since they have not been found yet. The learners can look at the annotated exploration history on their demand during exploration. They can also click the nodes in the history to review the content information, which they have inputted with Cut&Paste function.

Learners are not always required to input the above information whenever they visit nodes. Nevertheless, inputting the information during exploration may be troublesome for learners. On the other hand, it enables the learners to make their exploration more constructive, facilitating their exploratory learning. This point is discussed later in detail.

3.4 History Manipulation

Directly manipulating the annotated exploration history, the learners can reconstruct their exploration process without revisiting hyperspace. Each manipulation is done by means of mouse-clicking/dragging parts of the primary exploration processes. There are three basic manipulations: deleting and changing exploration purposes/links between starting and terminal nodes, and adding new primary exploration process.

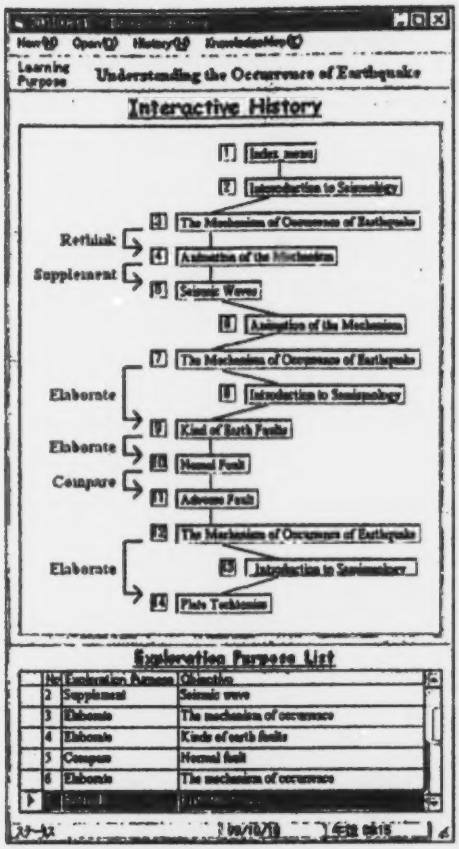

Figure 4. An Annotated Exploration History.

3.5 Knowledge Map Generation

In order to make the knowledge map understandable, we have adopted a visualization scheme shown in Table 1. This table shows the correspondence of an exploration purpose to a visual representation of the relationship between the starting and terminal nodes. For example, an exploration purpose to *Elaborate* is transformed into a set that visualizes the starting node as a total set and the terminal node as the subset. An exploration purpose to *Rethink* is also transformed into a visual representation that superposes the starting node on the terminal node. Following such correspondence, the system generates a knowledge map by extracting the primary exploration processes from the annotated exploration history. The knowledge map generation is executed on learners' demand before/after manipulating the annotated exploration history.

Figure 5 shows an example of the knowledge map that is generated from the annotated exploration history shown in Figure 4. Viewing this map, the learner can reflect on his/her knowledge construction. For example, he/she can recall that he/she rethought *The mechanism of earthquake occurrence* by exploring *The animation of the mechanism*. He/she can also recall that he/she compared *Normal fault* and *Adverse fault* to elaborate the description about *Kind of earth faults*.

3.6 Discussion

Let us now discuss several points to notice in utilizing the interactive history. The interactive history system requires learners to input information about primary exploration processes that have been carried out. Such inputting, in addition, requires a meta-cognitive skill that is indispensable for managing knowledge construction process in existing web-based learning resources. The interactive history system could distract learners, who do not have it, from their learning tasks in hyperspace. We believe, however, it is educationally important to train the learners to improve the meta-cognitive skill so that they can learn in the Web. The interactive history can be viewed as a potential tool for this training.

Before using the interactive history system, in addition, learners need to know how to interpret the visual repre-

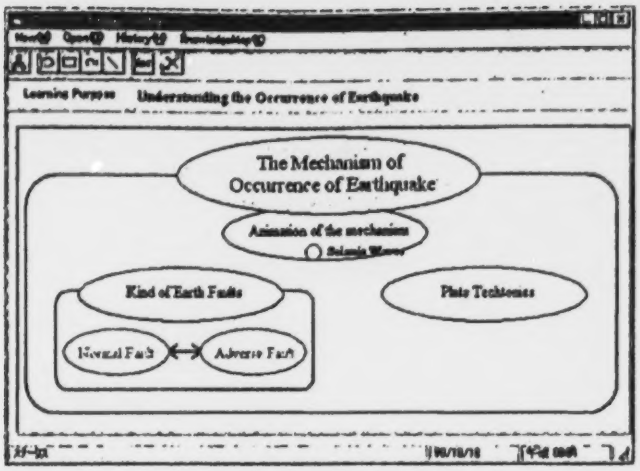

Figure 5. A Knowledge Map.

sentation used for the knowledge mapping. In order to explain it, the interactive history system demonstrates few examples of annotated exploration history and knowledge map before starting the actual learning support.

Let us next compare with related work on reflection support to consider the usefulness of the interactive history. The general browsers such as Netscape and Internet Explorer enable learners to revisit nodes with back buttons, and provide browsing history. However, these facilities do not always make the retention of their exploration processes easy [11]. As the retention support, there are several kinds of annotation systems that allow learners to take a note [1]. However, there is little discussion of what kind of annotation should be done for the success in exploratory and constructive learning. In the interactive history, we claim that the reasons why learners search for the next nodes should be particularly noted down.

Current work on adaptive hypermedia/hypertext systems has often provided spatial maps and concept maps as reflection support, which are originally used as navigational aid. Spatial maps display the nodes and links that compose the whole structure of hyperspace. These maps can visually represent the subspace where learners have already visited [4]. This subspace is represented as the partial structure of hyperspace. This visual representation can inform the learners where they are, what they explored, and to what extent they explored. However, the reasons why they visited the nodes are not clearly shown.

Concept maps consists of the nodes and links representing the structure of domain concepts to be learned. Each node is mapped on the corresponding node in hyperspace. The scope where the learners have already visited in hyperspace is mapped on the corresponding part of the concept maps. The learners can look at the partial structure of the concept maps to reflect on what they learned in hyperspace [5]. Such maps are more helpful for learners who have lower capability of exploring hyperspace in a constructive way since the direction of knowledge construction is visible to them. However, learners who have higher capability of the exploratory learning may identify semantic relationships among the domain concepts explored in a self-directed way, which relationships may be different to those defined in the concept maps [12]. In other words, they do not always construct the same knowledge structure as the structure of domain concepts that the designers of concept maps make.

The interactive history, on the other hand, provides the learners with a more proper support since it enables self-directed exploration and generates a knowledge map according to their exploration process. In addition, the interactive history can provide the reflection support even for most existing web-based learning resources of which concept maps are not prepared and even in ill-structured domains of which concept maps cannot be defined.

4 Preliminary Evaluation

4.1 Experiment

In order to evaluate the interactive history system, we have had a preliminary experiment. The main purpose of this experiment was to analyze the utility of the system and to ascertain if the interactive history improves learning compared to learning without the system. We also prepared two web-based learning resources, which had comparatively simple and complicated hyperspace, and ascertained in which resource the interactive history system enhances its own utility and facilitates learning more effectively.

Table 2 shows the two learning resource, which describes the number of nodes, and the number of links per node, which was calculated except for navigation links such as *Next*, *Back*, and *Top*. These can be viewed as the indicators of the complexity of hyperspace each learning resource provides. The learning resource 2 accordingly had a more complicated hyperspace. Subjects were five graduate and undergraduate students in science and technology.

We set four conditions, which were (1) learning in the learning resource 1 with the system (*Simple-With*), (2)

Table 2. Learning Resources.

	Learning Resource 1	Learning Resource 2
Number of Pages	73	161
Number of Links per Page	1.2	2.2

Domain of learning resource1: Mechanism of earthquake
Domain of learning resource2: Life in Sea

learning in the learning resource 1 without the system (*Simple-Without*), (3) learning in the learning resource 2 with the system (*Complicated-With*), and (4) learning in the learning resource 2 without the system (*Complicated-Without*). Subjects were provided with Internet Explorer as WWW browser under each condition. In this experiment, each subject learned one learning resource with the system, and learned the other without the system. In other words, he/she was assigned two conditions, which were *Simple-With* and *Complicated-Without* (or *Simple-Without* and *Complicated-With*).

Before learning, subjects were given a learning purpose for each learning resource. Under *Simple-With* or *Complicated-With*, they were also given the explanation about how to use the interactive history system, and were asked to try it in a sample learning resource whose hyperspace is simple. They were then asked to explore hyperspace with or without the system to accomplish the learning purpose. After subjects finished learning, they were given several problems about the contents for each learning resource. The problems were classified into (1) single problems whose answers could be found within one WWW page, and (2) compound problems whose answers could be found in the relationships among two or three pages. In this experiment, effects on learning were measured by the scores on both problems. The utility of the system was analyzed with the dispersion of pages visited, the number of revisit per page [11], the number of primary exploration processes executed, and the number of revisiting pages that were included in the primary exploration processes. Comparing the averages of them under *Simple-With* and *Simple-Without* or under *Complicated-With* and *Complicated-Without*, we evaluated the utility and effectiveness of the interactive history system.

4.2 Results and Discussion

Table 3 summarizes the analysis of the utility. The average numbers of revisit per page on both *Simple-With* and *Complicated-With* were slightly higher than the average numbers of revisit per page on both *Simple-Without* and *Complicated-Without*. The average dispersion of pages visited on both *Simple-With* and *Complicated-With*, on the other hand, was lower than the average dispersion of pages visited on both *Simple-Without* and *Complicated-Without*. In particular, the difference between *Complicated-With* and *Complicated-Without* was large. These results indicate that the interactive history system makes learners' exploration more intensive, particularly in a more complicated hyperspace. We further analyzed the utility of the interactive history system on *Simple-With* and *Complicated-With* as shown in Table 4.

Table 4 shows the average number of primary exploration processes executed, the average number of starting and terminal nodes (pages), and the average number of revisting pages that are included in the primary exploration processes. The average numbers of starting and terminal pages on *Simple-With* and *Complicated-With* corresponded to about half of the average numbers of pages visited as shown in Table 3 (56% on *Simple-With* and 52% on *Complicated-With*). In other words, half of the visited pages were related to the primary exploration processes. The average numbers of revisiting the starting and terminal pages on *Simple-With* and *Complicated-With* accounted for 67 % and 78 % of the whole revisits shown in Table 3. The ratio on *Complicated-With* was particularly high. These results indicate that the interactive history system can direct learners' attention to primary exploration processes, particularly in a more complicated hyperspace. In other words, the system can encourage learners to rethink exploration processes. This would improve learning.

Table 5 shows the average score of problem-solving on each condition. As for the single problems, the average scores on *Simple-With* and *Complicated-With* were lower than the average scores on *Simple-Without* and *Complicated-Without*. As for the compound problems, on the other hand, the average scores on *Simple-With* and *Complicated-With* were higher than the average scores on *Simple-Without* and *Complicated-Without*. In particular, the difference between *Complicated-With* and *Complicated-Without* were large. These results indicate that the interactive history system can produce good effects on learning such as integrating the contents of some nodes by means of exploration purposes, particularly in a more complicated hyperspace.

5 Conclusions

This paper has claimed that exploratory learning in hyperspace requires learners to reflect not only what but also why they have explored, and that the reflection support needs to adapt to their exploration process and knowledge structure being constructed by them.

This paper has also demonstrated the interactive history with knowledge mapping as a proper reflection support. The interactive history encourages learners to annotate and manipulate the exploration history to rethink their exploration processes. It also generates a knowledge map from the annotated exploration history, which allows the

Table 3. Analysis of Utility.

	Total Number of Pages Visited (a)	Number of Pages Visited (b)	Dispersion (b/a)	Revisit (a-b)	Revisit per Page ((a-b)/b)
Simple-With	69	19.5	0.283	49.5	2.53
Simple-Without	72	22.3	0.31	49.7	2.23
Complicated-With	67.3	21.3	0.317	46	2.16
Complicated-Without	59.5	32.5	0.546	27	1.25

Table 4. Utility of Interactive History.

	Number ofPrimary Exploration Processes	Number of Starting and Terminal Pages	Revisit
Simple-With	9.5	11(56%)	33 (67%)
Complicated-With	8	11(52%)	36 (78%)

Table 5. Avarage Scores of Problem-Solving.

	Total	Single Problems	Compound Problems
Simple-With	60.5%	75%	66.7%
Simple-Without	66.7%	91.7%	50%
Complicated-With	51.8%	55.6%	50%
Complicated-Without	41.1%	66.7%	25%

learners to reflect on what they have constructed during exploration.

In addition, this paper has described a preliminary evaluation of the interactive history system. Although we need a detailed evaluation with more subjects, the results indicate that the system facilitates a rethink on primary exploration processes particularly in a complicated hyperspace. The system can also improve learning, particularly integrating the contents of some WWW pages.

In the future, we will have a more detailed evaluation. We would also like to classify exploration purposes in detail to represent learners' exploration process more precisely.

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Models and Strategies for Promotion of Distance Learning in Primary Schools and High Schools

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The information education in Taiwan has been progressing rapidly since the Network Technology was adopted on a large scale.Under the Nine-Year Consistent Courses policy the by Ministry of Education, the information education will be integrated into other subjects and all teachers need to use computer and Internet resources to assist teaching .The plentiful education web sites on Internet also provide the student with materials for assisting learning .The essay presents the development process of information Education in Taiwan ;through it, we point out the obstacles we meet when promoting information education in primary schools and high schools.Meanwhile ,through introducing two education web sites :Gas Station for Learning and Schoolfellows' English Adventure Land, which were constructed in different models ,we offer the workable models and strategies for promotiing distance education in primary schools and high schools.

Keywords: **Distance Learning, Nine-Year Consistent Coures ,Teaching Material Resources Center, Schoolfellows' English Adventure Land**

1 Introduction

1.1 Analysis of Current Situation

"Nine-Year Consistent Syllabus" implemented in 2001, all schools will no longer especially establish the subject of Information Education, but enlist it in the learning area of "Nature and Technology." Nevertheless, in order to train students to have the basic abilities to make use of technology and information, teachers have to emphasize the application of information in the teaching of different subjects. And all teachers of different subjects are expected to take computer as a tool of instruction, integrate via network the traditional teaching materials and the teaching materials on Internet, and provide students with broader and more diversified learning resources.[2][3]

1.2 Problems Faced by Distance Learning:

To apply information education to the teaching of various subjects will really be a consistent trend in the education of Taiwan in the future. However, when confronted with the important educational reform, the actual implementation encounters difficulties because of Taiwan's restricted environment for information education.

The ratio of the number of class computers to the number of the students of a class is such a wide gap.If teachers are requested to use the limited computer classrooms to apply information to the teaching of various subjects, obviously, it is not an easy job to promote this at the current stage.[5][7]

2 Distance Instruction and Distance Learning

After the Ministry of Education implemented "Foundation Establishment Plan of Information Education," the computer and network equipment of various schools are increased. Besides, it also promotes the establishment of "Information Education Software and Teaching Materials Resources Center" at primary schools, junior high schools, senior high schools and vocational schools, in order to enrich the network teaching materials for subjects of primary schools and high schools.[1][8]

Besides, the famous distance instruction network of primary schools and high schools in Taiwan is illustrated as follows (Table1):

Web Site Name	Address	Institute	Object
Gas Station of Learning	http://content.edu.tw	Ministry of Education	Grade 1 to 12 student
Schoolfellows' English Adventure Land	http://192.192.186.8/seal/	San Hsin Institute of Housework and Commerce	Grade 1 to 12 student
Pathfinder	http://pathfinder.ntntc.edu.tw/	National Tainan Teachers College	Grade 1 to 9 student
Computer Assisted Instruction	http://www.wcjs.tcc.edu.tw/	Wu Chi Junior High School	Grade 7 to 9 student
Teaching Resource	http://www.ctjh.tpc.edu.tw/ctjh/resource.htm	Chiang Tsui Junior High School	Grade 7 to 9 student

Table1: Virtual Classroom Web Site for Grade 1 to 12 student

3 Teaching Materials Resources Center Focusing on Systematic Subjects

3.1 Concept and Idea:

The Ministry of Education in Taiwan starts "Foundation Establishment Plan of Information Education" not only to establish hardware environment, train teachers, carry out promotion activities, etc., but also to establish Information Education Software and Teaching Materials Resources Center, simply called "Education Resources Center" or "Gas Station of Learning."(http://content.edu.tw)

3.2 Outline of Resources Center:

The Ministry of Education advises various school to develop the on-line teaching materials of different subjects. The center can effectively integrate the resources of all primary schools and high schools and develop a series of network instruction resources with its own characteristics. "Teaching Materials of Subjects" are divided into four divisions: primary school, junior high school, senior high school and vocational school. In each group there are: 14 subjects in primary school, 19 subjects in junior high school, 17 subjects in senior high school, and 21 subjects of 4 categories in vocational school (the divisions of senior high school and vocational school was established in January 2000). The information integrated and collected by web sites cover the education resources of the Chinese's Five Education: virtue, wisdom, physical, group and aesthetics.

Through a united interface of users, it decreases the learners' load in adaptation to learning environment. The establishment of "Education Resources Center" is expected to achieve the following objectives: [6]

- Strengthen the applied network resources for teachers and students, and make the educational environment more diversified .
- Lay a foundation for a lifelong learning environment.
- Strengthen the quality and quantity of the resources of information learning so as to reach the aims of sharing of resources
- Shorten the distance between city and village [1]

4 Schoolfellows' English Adventure Land Focusing on Self-Learning

4.1 Concept and Idea

Teaching Materials Resources Center mainly edits the teaching materials according to the contents of the systematic teaching materials of various subjects. Therefore, they are suitable for teachers to adopt in class and for students to review after class. However, in the age of information explosion, the knowledge in books can no longer satisfy most of the students' thirst for knowledge. Therefore, with network being the media, distance education must have more diversified contents. It also has to create an interacting relationship between school and students. It can hold various kinds of activities and offer substantial awards to encourage all the students to participate. Then an activated distance learning environment can be created beyond system. Kaohsiung municipal government is positively involved in the activity. The "Schoolfellows' English Adventure Land , SEAL "(http://192.192.186.8/seal/) established by the municipal government at San Hsin Vocational School is based on this idea. It has the following characteristics :(1)Diversified Contents and Scope.(2)Individualistic Learning Environment.(3)Internet Learning without Limitation of Time and Space. (4)Flexibility of Time, Holding of Activities.(5)On-Line Contest,Internet Pen Pal Society.(6)Teacher Mechanism--Student Groups Management and Inquiry of Students' Learning Process:,Self-Made Test Paper Management:

4.2 Evalutaion on SEAL

The working group of Seal held an investigation in December 1999, towards the junior and elementary school teachers that used this website to assist their teaching. The questionnaire adapted Likert's five point scale from extremely disagree(1) to highly agree(5). In the 73 effectively retrieved questionnaires, there're 67 English teachers and 6 are not English teachers.

The statistics results of the questionnaire, in the curriculum arrangement and management session, show that sample teachers think the arrangement of the curriculum in SEAL is appropriate and the related activities that go with the curriculum is successful. (M=4.10 ,SD=0.82)。Sample teachers think that the recording of learning profile on the website of each student helps teachers to understand the student's learning style and problems.(M=4.26,SD=0.83)。Sample teachers think that the idea of designing language games and holding on-line composition contest is appropriate. (M=4.16,SD=0.83 ;M=4.03 ,SD=0.93)。About the learning interaction, most teachers thinks that English pen pal club will help to enhance the interaction between students, M=4.18 SD=0.93) . Most teachers think that SEAL is worth popularizing in assisting traditional learning. (M=4.59,SD=0.66)。

5 Workable Model and Strategy

In the implementation of distance education in primary schools and high schools, besides the consideration of the contents of teaching materials, how to make use of the characteristics of Internet appropriately to activate instruction is an important topic that cannot be neglected for discussion. Focusing on the above-mentioned analysis, we propose a model and strategies for distance learning be carried out in primary schools and high schools:

5.1 Four Elements for Activating Web Site:

According to the discussion above,there are four elements to activate the web site teaching materials :the content, interactivity, learning profile and activity. We have to take these four elements into consideration when designing the learning web site. The detailed function of the four elements is as follow:

5.1.1 Content

Text, image, sound , photo , animation chip and other mutimedia components should be included in an excellent education web site.Through multiple information styles supplied , the student can obsorb knowledge easily

5.1.2 Interactivity

With more interactivity function the education web site is more attractive and effective .The interactivity machanism encourages the student to use higher -level cognition skill..

5.1.3 Learning Profile

The learning profile lets the student know what he has learned and what to learn .The porfile also provides the teacher information about the student.

5.1.4 Activity

Not only in classroom but also in virtual classroom, well-designed activities are very important to improve the effectiveness of learning . Besides, through holding an activity , the student can cooperate and compete with others .

5.2 Strategy for Promoting Distance Learning

From this point of view, we will suggest applicable strategies for school administrators,teachers and students.

5.2.1 As for school adminstrator:

* **Establishment of Web Site by Full-time Professionals:**
The school administrator should know there should be full-time professionals to put teaching materials on Internet, hold Interact activities and carry out the maintenance work of systems.

* **Strengthening of Propaganda:**
The education departments or general affairs units of schools should positively introduce such an environment in the learning of students, and positively hold activities of relevant kind.

5.2.2 As for teacher and related professional:

* **Development of Excellently Activated Web Site:**
A web site must have substantial contents , diversified activities as well as interactivity machnism and learning profile to make the web site become a dynamic and lively learning environment.

* **Material Making:**
Teachers need not learn the establishment of web site. Teachers' job should be an all-effort studying of suitable contents of teaching materials for the learning of students.

* **Resource Assisted Teaching:**
All the related teaching web sites need the teacher to use them .Many web sites are well constructed ; however,few teachers use it to assist teaching . The teacher can provide the web site constructor with feedback for promoting the funciton or the rescources of the web.

5.2.3 As for Students:

* **Participate in activities :**
Only students' participation can make web sites activated and meaningful; otherwise, web site is merely an empty shell in a waste of information development.

* **Resource Assisted Learning:**
The student can make good use of on-line material to assist learning after class ; meanwhile , the student's feedback also helps the web constructor refine the web .

6 Conclusion

After the implementation of "9-year consistent" new syllabus in primary schools and junior high schools, information will be applied to various subjects and the application of network resources will become broader. The information-application-oriented network learning functions can be facilitated more effectively. The "Plan of Teaching Materials Resources Center" undertaken by Ministry of Education integrates various schools' resource to establish a garden that provides teachers with instruction resources and students with learning resources.The Plan not only can reach the purpose of resources sharing, but also decrease the load of learning through united interface environment. Besides, the distance learning environment beyond system, as provided in "SEAL," is also a good example for primary school students and high school students to involve in distance learning.

In term of positive implementation of information education, it is important to cooperate with the existing instruction environment and choose a workable model. For the government, based on the principle of effective utility of resources, it is necessary for her to integrate the establishment and the sharing of instruction resources. For schools, they have to encourage teachers and students to use Internet positively to assist in their teaching and learning. For teachers, they might not be required to allocate teaching materials on Internet, but they have to use the existing Internet resources and teaching materials positively, adopt suitable instruction methods, and correctly use Internet to communicate with students or parents. For students, they should meet the instruction of schools, use the teaching materials on Internet to assist in their learning, and learn new knowledge themselves.

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MULTIMEDIA DESIGN FOR CHEMICAL VISUALISATION

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In chemical or chemistry education, the ability to establish the connections among the three levels of understanding, namely, macroscopic, microscopic, and symbolic is an important task as this is fundamental to an understanding of chemical concepts. However, shortcomings such as limitations of textbooks in providing minimal images of macroscopic or microscopic events, time constraint and costs of laboratory experiments do exist, making achievement of the above essential task difficult for many students. Multimedia is one way to address these issues. As such, this paper concentrates on the pedagogical design for multimedia instruction in terms of instructional storyboarding and relevant learning principles. Visualisations such as computer graphics or animations and videos that elicit effective visual and verbal information processing will be illustrated using the topics of electrolysis, organic chemistry and acids, bases and salts.

Keywords: **Multimedia design; Interactive learning environment; chemical education**

1 Introduction

In the teaching and learning of chemistry, three understanding levels have been identified (see [1, 2] for more details). They are (a) the macroscopic level, which deals with sensory/ visible chemical phenomena such as laboratory observations and data; (b) the microscopic level, which deals with particles such as atoms, ions and molecules; and (c) the symbolic level, which represents the matter in terms of chemical formulae and equations. Students are required to demonstrate transfer between the phenomenon and its atomic or molecular events and symbolic representations.

However, this seems to be difficult for many students (see [3, 4] for more details). As such, multimedia CD-ROMs integrating various presentation modes such as sound, text, images, videos, graphics, and animations may be used to address this issue of the students' difficulties. Hence, this would call for an appropriate and practical multimedia design with an emphasis on dual coding of verbal and graphical information that would elicit effective visual and verbal information processing.

2 Multimedia Design

In multimedia design, one needs to consider the research in learning styles and "multiple intelligences" which imply that some students learn better through specific presentation modalities, such as visual, audio, or kinaesthetic. Essential design decisions such as determining the goal of the instruction and the pedagogical approach where learners are to be engaged not only in meaningful authentic tasks but also in constructing meanings with the visualisations employed need to be processed (see [5] for more details).

As such, important chemistry modules such as electrolysis, organic chemistry and acids, bases and salts are developed as part of a courseware with these design considerations in mind using C++ programming language and Director 6 to help students who take chemistry at the General Certificate of Education Ordinary Level.

3 Developing Visualisations

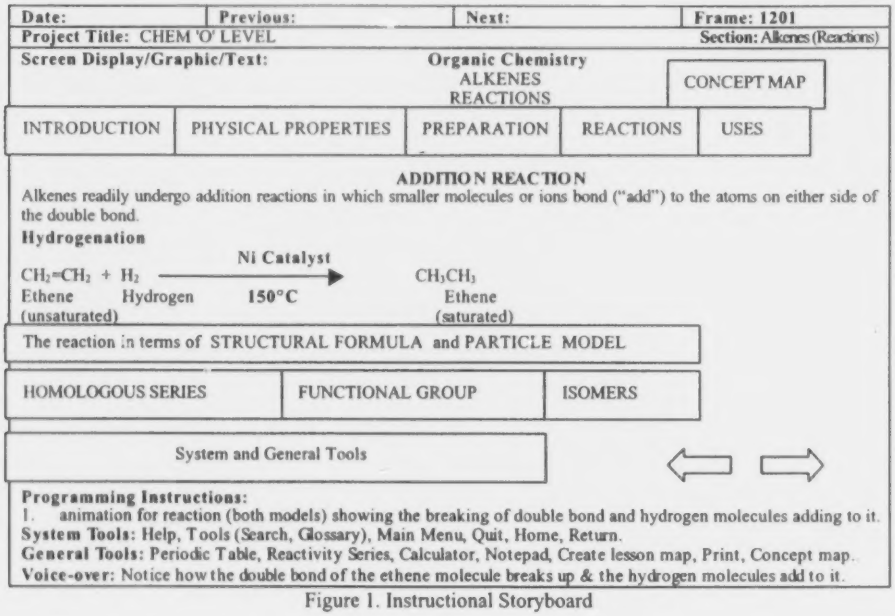
The first step in the development of visualisations in chemical or chemistry education is to identify the specific chemical concept or principle to be learnt for the particular subtopic. The next step will be to decide on the instructional use of the materials for purposes of expository teaching, demonstration, tutorial, group or individualised learning.

Subsequently, instructional storyboards will need to be constructed. Therefore, the following learning and design principles need to be taken into account. For example, integrating new knowledge with existing knowledge; organising system features logically and functional to facilitate the learning process; reducing the cognitive load on the learners through proper screen interface design and navigational procedures as well as employing the principle of progressive dis closure (see [6, 7] for more details).

Besides, the storyboard should contain as much information as possible on how the visualisations are to be displayed. Figure 1 shows the instructional storyboard on the addition reaction of alkenes while Figure 2 illustrates the translation of this storyboarding into the actual product. Notice also the emphasis placed on the different size, colour and shape of the atoms involved and the breaking of the chemical bonds in the animation which are essential in order to enhance the understanding of the meaning of "addition" in this organic chemical reaction.

As such, an understanding of the principles in using animation (see [8, 9] for more details) to address the three levels of understanding in chemistry is important so that relevant and appropriate animations can be employed in a concrete way to depict certain molecular events.

Figure 3 shows animations for the purpose of understanding the relative ease of losing electrons. The interactivity designed is functional in that opportunity is given to the user to discover and construct knowledge and understanding of the discharge of an anion with regard to its relative ease of losing its electrons.


Date:
Previous:
Next:
Frame: 1201
Project Title: CHEM 'O' LEVEL
Section: Alkenes (Reactions)
Screen Display/Graphic/Text:
Organic Chemistry
ALKENES
REACTIONS
CONCEPT MAP
INTRODUCTION
PHYSICAL PROPERTIES
PREPARATION
REACTIONS
USES
ADDITION REACTION
Alkenes readily undergo addition reactions in which smaller molecules or ions bond ("add") to the atoms on either side of the double bond.
Hydrogenation
Ni Catalyst
CH2=CH2 + H2
150°C
CH3CH3
Ethene (unsaturated)
Hydrogen
Ethene (saturated)
The reaction in terms of STRUCTURAL FORMULA and PARTICLE MODEL
HOMOLOGOUS SERIES
FUNCTIONAL GROUP
ISOMERS
System and General Tools
Programming Instructions:
1. animation for reaction (both models) showing the breaking of double bond and hydrogen molecules adding to it.
System Tools: Help, Tools (Search, Glossary), Main Menu, Quit, Home, Return.
General Tools: Periodic Table, Reactivity Series, Calculator, Notepad, Create lesson map, Print, Concept map.
Voice-over: Notice how the double bond of the ethene molecule breaks up & the hydrogen molecules add to it.
Figure 1. Instructional Storyboard

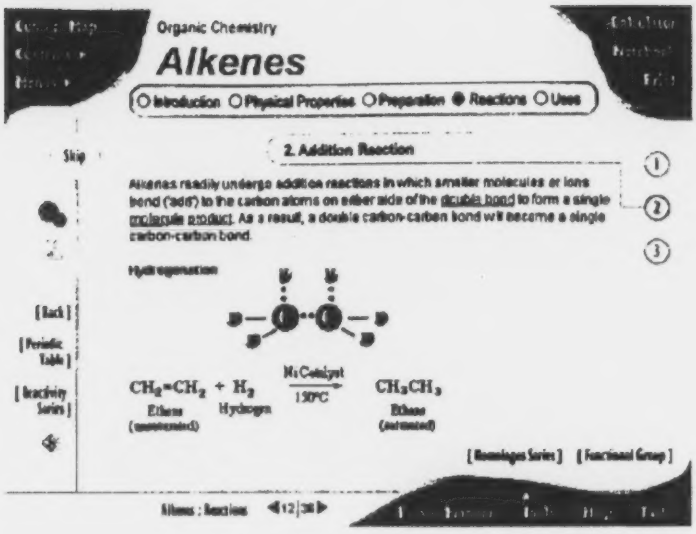


Figure 2. Organic chemistry user interface

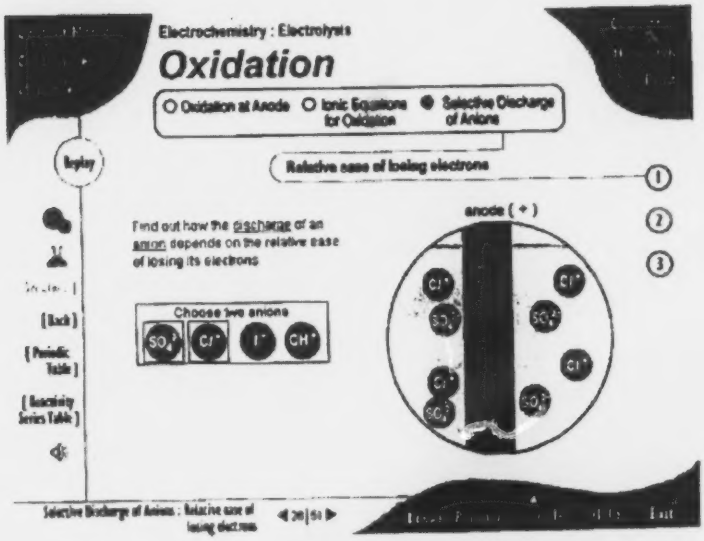

Electrochemistry : Electrolysis
Oxidation
Oxidation at Anode
Ionic Equations for Oxidation
Selective Discharge of Anions
Relative ease of losing electrons
Find out how the discharge of an anion depends on the relative ease of losing its electrons
Choose two anions
anode (+)
[Back]
[Periodic Table]
[Reactivity Series Table]

Figure 3. Electrochemistry user interface

4 Conclusions

The importance of content design will continue to be paramount even in the most advanced created multimedia technological environment. Animation, an example of computer graphics, can be used effectively to help learners to perceive and process information thereby increasing the depth and fluency of learning. Equally important is the pedagogical approach in the design of the multimedia courseware, which needs to be selected and understood.

From what we have observed, the development of visualisations in chemistry or chemical education is not a one-way process with arrows going in one particular direction through a flow chart, but rather an iterative process. Also, an overall multimedia design especially in the aspect of logical and functional consistency would be required. Despite the complex nature of chemistry multimedia courseware design, technological advances are providing dynamic new design and development opportunities. However, the development of sound pedagogy based on educational theories is still of primary importance. Essential issues, for example, the kind of methodology needed for the learning materials to be organised and structured; the type of navigation patterns to be employed; and how best the design and development process to be approached need to be fully addressed to realise the potential of such multimedia courseware.

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Multimedia Intelligent Tutoring System for Context-Free Grammar

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CFG-MINTS is a multimedia intelligent tutoring system that teaches context-free grammar. The tutor model of his ITS is composed of a set of teaching strategies and an algorithm that determines which teaching action to be deployed given the goals of the system and the current state of the student model. The student model uses the Constraint-Based Modeling (CBM) approach in diagnosing the learner. CBM reduces the complexity of student modeling by focusing on the difference of the student' s solution to the ideal solution only and the analysis is reduced to pattern matching. The assumption here is that there can be no correct solution of a problem that traverses a problem state, which violates the fundamental ideas, or concepts of the domain. The system also includes features for simulating the created context-free grammar to aid in teaching.

*The paper was not available by the date of printing.

Multimedia Whiteboard Design in* WWW-Based Remote Cooperative Education System

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Computer Supported Cooperative Work (CSCW) is combined into the remote education, and the WWW-based Remote Cooperative Education System (RCES) is designed and realized in the paper. RCES adopts Browser/Serer model and makes users be able to run the client over the Internet without the need of installing special client software. And the real-time communication tool in RCES - multimedia whiteboard is also designed and realized which is also the major tool of CSCW. A set of Control Transport Protocol (CTP) is proposed to transmit the data and realized with Java and Java Media Framework (JMF). The new system enhances the interaction capability and realizes live transmit of multimedia data including graphics, images, audio and video etc.

Keywords: **CSCW, RCES, CTP, whiteboard**

1 Introduction

The theory of Computer Supported Cooperative Work appeared along with the progress of society, development of science and technology and raise of the complicated level of work. It provides a "being face-to-face " and What You See Is What I See (WYSIWIS) environment for the users scattered on different time and in different space and makes it possible for computer system to raise group work efficiency as well as traditional individual work efficiency. Since Engelbart first demonstrated CSCW in the 1960s, a variety of CSCW applications have developed at several research laboratories and universities. Education is an inherently cooperative activity involving at least one teacher and one student. Now, we combine CSCW into remote education, design and realize the WWW-based Remote Cooperative Education System (RCES). It adopts Browser/Server model and makes users can run the client over the Internet without the need of installing special client software.

Whiteboard is an important tool in the WWW-based RCES. The whiteboard provides a real-time interactive environment among people. In the traditional education, teacher and students face to face exchange their opinion through blackboard in classroom. While in the WWW based RCES on-line exchanging opinion and consulting are fulfilled through whiteboard over the Internet. Except the basic function, the whiteboard adds some functions such as drawing, loading images etc. The existing whiteboard system can roughly be divided into two kinds: systems based on Client/Server model and systems based on Browser/Server model. The whiteboard based on C/S model can solve well the interaction problem and provide powerful function for users. Its defect is that the users have to install the client software as server does. That limits the application scope of the system. Compared with it, the whiteboard based on B/S model can run over the Internet and the client doesn't need special software, but a

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browser such as IE or Netscape navigator is needed. Apparently B/S model gives a more convenient environment to the users. But its interactivity is less than C/S model and most present whiteboards based on B/S model only transmit the information such as texts, graphics, images, but do not support the transmission and playback of the time-based information such as audio and video.

We design and realize a new real-time communication tool in RCES—multimedia whiteboard that is also the major tool of CSCW. It absorbs the advantage of systems mentioned above. New system adopts B/S model

and makes users can run the client over the Internet without the need of installing special client software. In addition, we design a set of Control Transport Protocol (CTP) in order to transmit the data and implement it adopting Java and Java Media Frame (JMF). Compared with the present whiteboard, the new system enhances the interaction capability and transmits multimedia data lively including graphics, images, audio and video etc. And the live audio and video can be transmitted and played back on this new whiteboard to make the system more practical.

2 Control Transport Protocol Design

TCP/IP and UDP are the major protocols of the Internet and they are well supported by Java. The multimedia whiteboard runs over the Internet, so the system is mainly based on TCP/IP. When multimedia information is transmitted, Real-time Transport Protocol (RTP) is used, which is a protocol based on UDP so as to get better playback effects. In order to transmit and deal with the system information over the Internet, we design a new control protocol of application layer—Control Transport Protocol (CTP) that is special for the whiteboard system. We design it on the basis of the whiteboard function and build it in the request/response model.

Owing to assuring the accuracy of data transmission by TCP / IP, therefore, the design of CTP should be as succinct as possible under the promise that the function is guaranteed.

The CTP set can be represented as a multi-element set (D, F, n, a_1, a_2, … a_n). Here D represents the transfer direction. If data is transmitted from server to client, and then D="S", whereas D="C"; F represents the catalog of transfer data. For example, if a user wants to transmit the login data, and then F="login"; n represents the number of associated information and the concrete associated information is represented by a_1, a_2, … a_n. For a line, n=6, a_1="line", it is one of graphics styles. a_2 =color of paintbrush, it is an integer, a_3, a_4, a_5, a_6 are the starting and end point coordinate of this line. If the number of associated information is uncertain, and then n=-1, the subprotocol is ended with "ok". This protocol set can be expanded easily. For example, we want to transmit the polygon, we can add ("C","polygon", -1, the color of paintbrush, abscissa of starting point, ordinate of starting point, abscissa of the second point, ordinate of the second point, …abscissa of end point, ordinate of end point, "ok") to the CTP set.

Table 1 Control Transport Protocol Set

Tasks	Protocol
User applies* to join in a discussion room	("C", "join", 1, the topic of discussion room)
User applies to pause the communication	("C", "pause", 0)
Server demands** to refresh the room and the user lists	("S", "refresh", -1,the topic of room 1,the user 1's ID in the roon $_1$,e the user 2's ID in the room $_1$, "complete", the topic o room $_2$,e the user 1's ID in the room $_2$…"complete", the topi of room $_n$ the user 1's ID in the room $_n$,"complete", "ok")
User applies transmit the graphics	("C", "draw", 6, graphics style***, the color of paintbrush, ab scissa f of starting point, ordinate of starting point, abscissa o end point, ordinate of end point)
Server demands transmit audio data	("S", "audio", 1, IP Multicast address)

Note: * The data from client is transmitted to server only;
** The data from server is transmitted to all clients in the same room;
*** The style of graphics includes line, point, oval and rectangle etc.

3 The method of solving key problems

The whiteboard is a major tool to help the cooperative education system to fulfill the cooperation. We have solved the key problems including technical problems about CSCW, problems occurred during multimedia transfer and so on. The method of solving key problems in the whiteboard is described as following:

1) The method of solving CSCW technical problems in the whiteboard

CSCW technical problem generally includes role-control, data consistency, conflict clearing, concurrency control and so on.

① Role control
Every user who logs in the system will play a role. In the education system, users are divided into 2 class: Teachers and students. By means of User ID, users get their roles and authority from existed user information database soon after they log in. Then according to their different roles and authority, related system functions are given.

② Data consistency
We use the method of Client/Server to solve the problem of data consistency. The whiteboard server maintains a set of global data and the data on each client PC are same as those on the server. When users operate with the data on client PC, this PC sends message to the server first. The server updates the global data and then informs the clients of the modification. At last, the clients update local data to keep the coherence of the whole system.

③ Conflict clearing
The conflicts in whiteboard mainly refer to data resource conflicts during transfer. They are due to the limited bandwidth and the high frequency outburst during data transfer. When several users send data at the same time or a certain user sends a mass of data, the congestion will occur in the web. Hence, data may be discarded or errors may be caused. Further, valid data have to be sent again and the congestion will be more serious. This problem is solved by way of data priority (PRI) when designing the system. That is to send the vital data first. Data PRI can be divided into 5 levels. They are listed in orders from higher to lower. i) Data such as users login information or screen-refreshing data, because these data will influence all users; ii) texts and graphics; iii) images; iv) audio; v) video. Data in higher level are always sent first.

④ Concurrency control
Concurrency control mainly indicates the conflict of shared resource used by users at the same time. Solving this problem is very important to fulfill cooperation; this factor must be taken into account in. Because the system belongs to distribute one, hence the concurrency control is very complex. Typical method of dealing with concurrency is the locking or time stamp. Relatively, the former is more simple and valid. The method of locking is adopted in the paper.

In our Server/Client system, synchronous block is created in each subprotocol of the protocol set. All operation of the subprotocol is performed in its synchronous block, so as to limit output stream or input stream that accesses to the web at random. As a result, when a thread processes a subprotocol, it can monopolize the shared resource and the other threads cannot access the resource. Thus a thread is able to process a subprotocol without disturbance from the other threads and system error can be avoided. The disadvantage is that efficiency of thread operation will be decreased. So the code in a synchronous block should be limited as little as possible under the promise of correct subprotocol operation.

2) The method of solving problems in the multimedia transfer

Multimedia information can be divided into 2 classes. One is information irrespective of time, such as text and graphics. The other is time-based information, such as audio and video. Because audio or video restrictively demands real time, discarding errors and ignoring lost data will achieve better effects. So audio and video information are transmitted by the way of UDP-based real-time transport protocol----RTP. It provides real time media transport services, such as live audio or video. These services include data type, sequence number, time stamp and transfer supervising. In fact, RTP itself cannot fulfill data-transmitting service without the help of protocols in lower level of the networks. The head of each RTP data packet includes time stamp and sequence number. With the time stamp, the receiver can resume the original data sequence. With the sequence number, the receiver can deal with lost, repeated or error data packet.

On the other hand, because the audio or video information is usually a large amount, and needs long time to transfer, it will take up too high bandwidth. In the situation of multi-users over the Internet, the method mentioned above cannot achieve good effects. We take advantage of IP Multicast Technique to save bandwidth, and the transferring and playing back audio or video smoothly in narrower bandwidth can be realized. IP Multicast Technique is a complement to the standard protocols of network level. It uses D-Class IP address

that possesses the same byte length as A-Class, B-class or C-Class address. And the scope of D-Class address is from 224.0.0.0 to 239.255.255.255 in decimals.

D-Class address is a kind of temporary address that is assigned and recovered dynamically. Each multicast group is corresponding to a dynamic D-Class address. After the multicast group finishes, its related D-Class address will be taken back to be used later. D-Class IP address is the multicast address for a whole group and the members in this group share the same D-Class IP address. So the information from the source node is sent only to members in this group. Furthermore, only one packet is sent to the site on the same route and the action of copying is performed only when needed. This process is different from point-to-point system (in point-to-point system, each destination site needs a copy). So we are able to save lots of bandwidth resource, increase the members on networks and eliminate the aimlessness of broadcast with the multicast way.

Because the standard JAVA API doesn't support transfer and playback of video information, the Java Media Framework produced by Sun Company can be applied. In fact JMF is a group of Java class library, which is created specially to remedy the incomplete support to multimedia in Java. JMF collects and plays multimedia data in Java applications or Java applets. JMF itself supports both RTP and IP Multicast Technique, so it is very convenient to transmit and play audio or video back with JMF.

4 Multimedia information flow

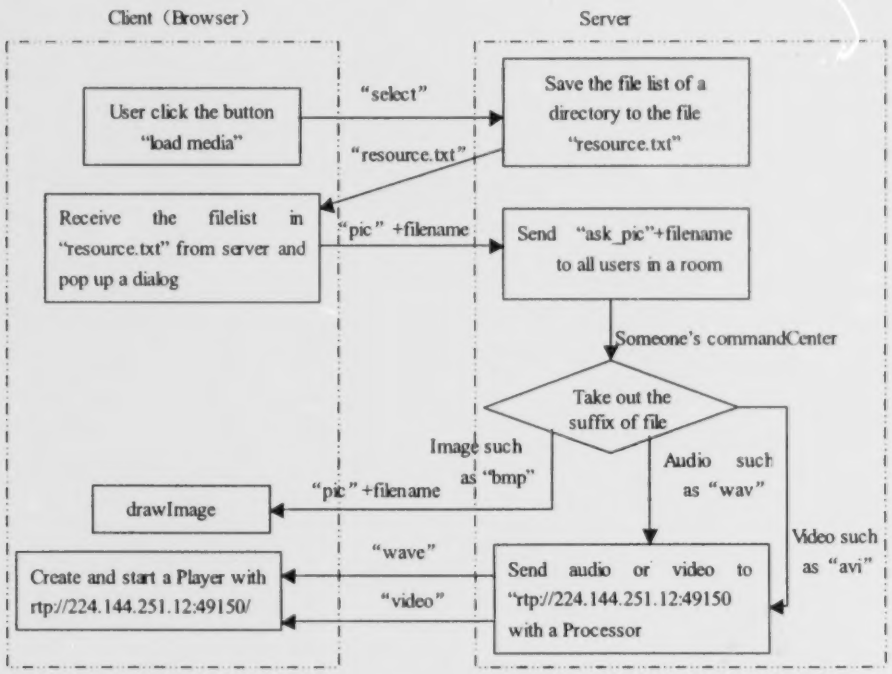
Client（Browser）
Server
User click the button "load media"
"select"
Save the file list of a directory to the file "resource.txt"
"resource.txt"
Receive the filelist in "resource.txt" from server and pop up a dialog
"pic" +filename
Send "ask_pic"+filename to all users in a room
Someone's commandCenter
Take out the suffix of file
Image such as "bmp"
Audio such as "wav"
Video such as "avi"
"pic" +filename
drawImage
"wave"
"video"
Create and start a Player with rtp://224.144.251.12:49150/
Send audio or video to "rtp://224.144.251.12:49150 with a Processor

Fig.1 Multimedia information flow

Multimedia information flow is as shown in the figure 1. Taking the example of transmitting loaded multimedia information, the system flow is given out while users discuss using the whiteboard. When a user wants to load multimedia on the client, the client will send message ("C", "select', 0) to the server, which indicates the user wants to select loaded files. On receiving this message, the Sever sends a file list that is stored in a file named as "resource.txt" to the client. Then the client reads the file list out of that file and displays it in a new file-selecting dialog box. Hence the user can select the file that he wants to load and the message ("C", "pic", 1, filename) is sent to the server.

After the server receives this message it sends the message ("pic"+ filename) to every user object that belongs to the server. Please note that this message is sent not to the client side but to the related user-information object in the server. According to the suffix of the file, the server knows it is an image, an audio or a video file that is needed by the client. If a picture is wanted, a message ("S", "pic", 1, filename) is sent to the client and the client calls drawImage () function to present the image by its filename. If the audio or video is wanted, the Server will create a D-class multicast address and send multimedia data to this address. Meanwhile the Server sends to each user in the room a message "audio"(in case of audio data) or a message "video" (in case of video data). Thus the clients are informed to join in the related multicast address so that the audio or video can be played back.

5 Conclusions

In order to test the performance of new system, we not only apply text, image, animation, and drawing graphic, but also apply most challenging time-based media – audio and video – to this system. The result is rather good (Testing condition is: rate of network is over 40 Mbps, one server and 5 concurrent users, on-line transferring and playing back audio and video).

Remote education is an application on networks that develops rapidly in recent years. With the never stopping development of network technique and multimedia technique, the users' demand on remote education will be higher and higher. We combine CSCW technique into remote education and make the system possess more and better mutual functions. Based on the past man-to-PC mutual mechanism, we add man-to-man mutual mechanism to the system. Now the educating process becomes more vivid, and better education effect is achieved.

The real-time communicating ability of most B/S model software in present cannot satisfy the users' demands. Taking this factor into consideration, we design and use CTP to transmit control message and non-time-based media information and combine RTP and IP Multicast Technique with CTP to fulfill the transfers and playback of multimedia information. Hence the real-time communication ability of the system is enhanced. Compared with the present whiteboard in B/S model, the system has stronger function in transmitting the multimedia. It can't only transmit the audio and video in files, but also can transmit the live audio and video to get better effects in education. The students can hear or see the teacher and communicate with him or her in real time.

Though most present software in B/S model are weaker than those in C/S model, the convenience that they possess provides a large latent market. Furthermore, with the development of the browser and other related techniques, the functions of software in B/S model will become more and stronger. In a word, the prospect of software in B/S model is promising.

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Multimedia-Based Teaching Material For Learning Digital Signal Processing

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In acoustic engineering, it is very difficult to understand a phenomenon of a wave inside of a media, because these phenomena are invisible. In education of digital signal processing, it is related to improve the educational effect, that the method to help understand to modelize these phenomena. In this research, the digital signal processing teaching material, which used the multimedia, was designed and developed.

Keywords: **Education of Acoustic Engineering, Multimedia, Digital Signal Processing**

1 Introduction

In Education of Acoustic Engineering, it is very important to promote better understanding about a wave or a sound. It is difficult for students to confirm the theory, because of them invisibleness. If a sound can be visualized, it is very easy to understand them. The concretely samples of acoustic engineering are closely connected with our daily life. So, it is very important to present the relative movies, music, or synthetic sounds. It becomes to better effects of education.

By the way, computers get speedier CPU and larger volume of hard disk, and software for presentation and visualized languages, which have a graphical user interface, is improved. These things made easy to visualize a difficult simulation, and to playback a movie and a sound. [1-3] In this research, the digital signal processing program that requires using it in the lecture to improve student's understanding is developed.

2 Theory

2-1 Discrete Fourier Transform (DFT)

The Fourier Transform is a method of converting a complex signal into a lot of sine wave groups. Analog signal that is continued cannot be treated in case of the Fourier transform on the computer. Therefore, discrete data will be treated. It is called Discrete Fourier Transform (DFT).

Figure 1 shows the process of DFT. A wave sampled by computer. The sampling condition has the sampling rate and the number of making to the quantum. The shape of waves that changes in detail cannot be read when the sampling rate lowers to the maximum frequency included in the input signal, and the shape of waves of the phantom is sampled. This phenomenon is called Aliasing error, and the appearance is shown in Figure 2.

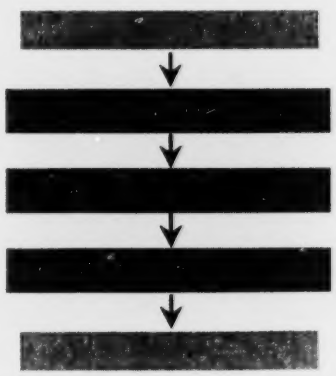


Fig1. Flow of Processing
until signal analyzing

So as not to generate Aliasing error, when the frequency of the wave input to the computer is assumed to be f, the sampling cycle should be at least $2f$ or more.[4]

When one cycle of a certain continuous crimp is sampled by equal intervals, the data row of P piece(f_0, f_1, f_2, ... , f_{P-1}) is obtained. When DFT is calculated by using this data row, f_N becomes the next expression.

$$f_N = \sum_{M=0}^{P-1} a_M e^{j(2\pi/P)MN} \qquad (2\text{-}1\text{-}1)$$

In general DFT, the next expression is used to obtain the coefficient(a_0, a_1, a_2, ... , a_M) of the above expression.

$$a_M = \frac{1}{P} \sum_{N=0}^{P-1} f_N e^{-j(2\pi/P)MN} \qquad (2\text{-}1\text{-}2)$$

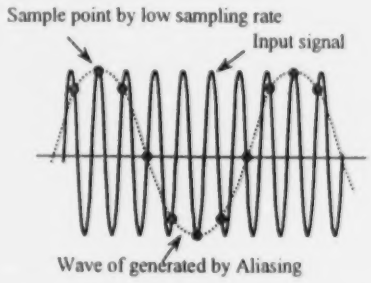


Fig 2. Appearance of Aliasing error

In the above expression, P shows the number of sampling for one wavy cycle and M shows the degree of a high note wave.

In this method, however, to obtain all the coefficient rows, addition and the multiplication by the complex number are needed. So, a lot of calculation time is required.

2-2 Fast Fourier Transform (FFT)

In this program, the method of decimation in time is used as a method of Fast Fourier Transform. It is one of the methods for the high-speed enabling processing.
The expression is the following.

Previously, a part of complex function value which is used frequently shows as expression (2-2-1).

$$W_P^M = e^{-j(2\pi/P)M} \qquad (2\text{-}2\text{-}1)$$

And the following relation exists because W_P^M has the cycle of P.[4]

$$W_P^{M+P/2} = -W_P^M \qquad (2\text{-}2\text{-}2)$$

Therefore, the expression which uses the method is the following expression (2-2-3) and (2-2-4).

$$a_M = a_{EM} + W_P^M a_{OM} \qquad (2\text{-}2\text{-}3)$$

$$a_{M+P/2} = a_{EM} - W_P^M a_{OM} \qquad M=0, 1, 2, \ldots, P/2\text{-}1 \qquad (2\text{-}2\text{-}4)$$

At this time, the M[th] coefficient a_M of DFT data that calculated by data-row including data of P, could be changed to 2 data-rows, which are the even data-row a_{EM} and the odd data-row a_{OM}. These rows are composed by $P/2$ piece. EM and OM, affixing characters of a, explain order of even-row and odd-row.

The principle chart in this method is shown in Figure 3. It shows, if the number of data is made involve piece of two by using this method, it is divided consequentially into two DFT groups.

By this method, the DFT calculation of the data of P piece decreases from times of P^2 to times of $(P/2)\log_2 P$. In addition, doing high-speed DFT becomes possible because the addition frequency also decreases the level.

3 Teaching Material Development

3-1 Development Background

The lecture of Acoustic Engineering in our department is lectured with the multimedia style by using the LCD projector and the notebook-sized personal computer. The multimedia contents that used by presentation are composed of the slide simulation program and the dynamic scene, etcetera. The lecture consists by the main explanation and a supplementary explanation. That is, the former uses the main slide and the latter uses the simulator teaching material of the phenomenon in Acoustic Engineering.

In a past research, we have developed the teaching material, which is multimedia-based for learning Fourier Transform. It is shown in Figure 3. Moreover, it actually uses in the lecture of our Department and an educational effect has been improved.

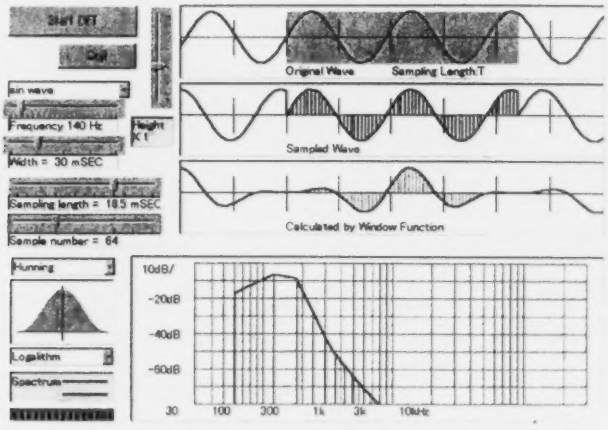


Fig 3. A program of DFT Analyzer

3-2 Execution Program

This program enhances the above-mentioned teaching material. That is, the analysis teaching material of sound to improve understanding voice-print analysis and filter is developed. The voice-print can be analyzed by applying DFT. The analysis result can judge the character of the voice. On the other hand, the filter is an application of DFT as well as the voice-print, too. We can extract an arbitrary frequency and do masking by using the filter. If these phenomena can be made visible, and the sound in that case is output, the understanding of the student will be improved.

For development of teaching material, the user interface part uses Microsoft Visual Basic (VB), and the FFT calculation part uses Microsoft Visual C++ (VC++). As this reason, the former has already had GUI(Graphical User Interface) parts and the latter can execute a numeric calculation at high speed.

This teaching material is required to be used with the projector with a remote-controlled mouse. Therefore, the following two points are important.

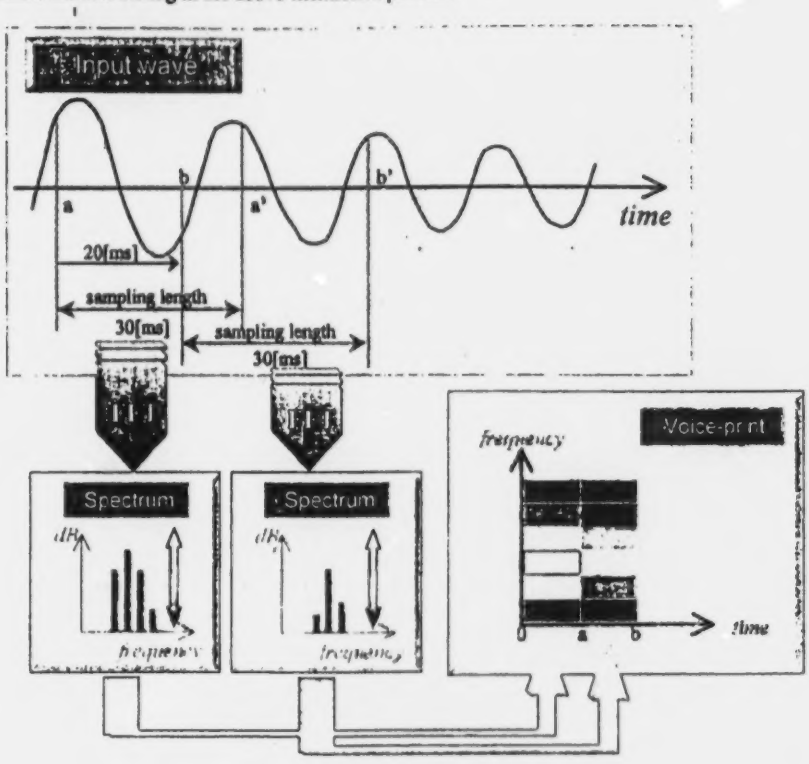
To reduce the load of those who operate it, the frequency of the click is reduced as much as possible.
To use by the lecture is considered, a detailed character and the image keep from using, and enlarge an important wave display.

It is necessary to design the screen based on the above-mentioned theory.

Figure 4 shows the flow of the program. First, it is necessary to cut out the input wave. The section samples it with about 30[msec], from a to a'. Next, the window-function and FFT must be processed to the obtained sampling wave. Then, it becomes spectrum of each frequency. Finally, in the obtained spectrum, a strong part is classified as white and a weak is classified as a black by each frequency element. And, the section shifts in 20[msec], and the part of the following 30[msec] is sampled and input again. The Frequency-Time graph obtained repeating these process is a voice-print. And digital filter extracts and masking a specific

frequency in the graph.

This program has a flexible setting in the above-mentioned process.



Appearance of Aliasing error

4 Conclusions

In this research, the multimedia-based teaching material of digital signal processing that used in the lecture of Acoustic Engineering was designed, and developed. In using this in the lecture of Acoustic Engineering, It is thought that this teaching material can help understanding the phenomenon, in digital signal processing. Moreover, it is possible to apply it also to large-scale education and the distant place education by developing this program for the network.

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Agents in a WWW System for Academic English Teaching

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This paper describes our research on building a free, evolutionary, Internet-based, agent-based, long-distance teaching environment for academic English. Here we will describe some of the design aspects of the system prototype, focusing especially on the adaptive features and the agents of the system.

Keywords: **Distance Education, CALL, Agent Technology**

1 Introduction

As distances constantly grow smaller and the Internet links more and more remote parts of the world, English gradually becomes the lingua franca for information exchange. In the academic field, in research and development, where international cooperation is a must, English is used frequently. Academic English is International English. Although accents are more or less variable, the spoken, but mostly, the written academic language has still its rules and etiquette. Academics usually know some English and have a more or less wide English vocabulary. However, especially in Japan, but in other non-English speaking countries as well, there exists the phenomenon that, although a person can read academic papers in English, when it comes to writing a paper by oneself, or to make an academic presentation in English, serious problems appear. Therefore, we embed these necessary rules and etiquette in our teaching environment. The main aim of our system is to help academics exchange meaningful information with their peers, through a variety of information exchange ways: academic homepages, academic papers, academic presentations, etc. As far as we know, this type of English teaching system is new. Some English teaching environments on the Web appeared, but, as in [1] or [11], they have two main defects: they are not free, and/or they are not automatic, but based on real human teachers at the end of the line. Good on-line dictionaries [12], [8] and several collections of English on-line books [2] exist, but those can only act as auxiliary helpers during the English learning process. Our aim is to have a system capable to function autonomously, without human interference, as a virtual, long-distance classroom, embedding the necessary tutoring functions within a set of collaborating agents that will serve the student. The course is called 'MyEnglishTeacher', because of its evolutionary nature, of adapting over time to the needs and preferences of individual users. These needs can be expressed explicitly, or can be implicitly deduced by the system, represented by its agents. We are currently in the process of adding more AI-based intelligent adaptation capabilities. Users can find in our virtual classroom situational examples of academic life, presented as Multimedia, with Audio and/or Video presentations, Text explanations and pointers to the main patterns introduced with each lesson, exercises to test the user's understanding, moreover, adaptive correction, explanation and guidance of the user's mistakes. The general guidelines for this system were proposed by our course design researcher in [3] and elaborated by us in [6].

2 Background

Virtual environments in education and distance-learning systems are the recent trends in education worldwide. This trend is determined by the current spread of the Internet, as well as by a real demand for better, easy-to-access, and cheaper educational facilities. Therefore, universities everywhere respond to the academic demand for technological and pedagogical support in course preparation, by developing specialized software environments [5]. As bandwidths grow, the traditional text environments gradually switch to multimedia and Video-on-Demand (VOD) systems ([17]). The problems in the current language

education systems, as well as the motivation of our research, as pointed out by our language specialist team member and [15], can be resumed as follows: the lack of learning activities for checking learners' constructive understanding (requiring the learner not only to memorize, but also to summarize, generate, differentiate, or predict); the lack of a variety of problem-solving tasks to motivate students to think about their reading; the learning process does not enable learners to become active participants; in the current Computer Aided Language Learning (CALL) systems, learners cannot key-in the target language's sentences freely; lack of explanatory feedback (telling the user why); lack of exercises related to the learner's individual characteristics; lack of considerations about the effectiveness of different physical attributes of the presentations, on the students' learning; lack of analysis of the interaction between learner and learning environment, with special focus on assimilation and accommodation. These problems could not be solved by traditional systems, mostly due to their lack of adaptability, or in other words, intelligence. In [19], it is stated: "there is the need to endow these systems with the ability to adapt and learn, that is, to self-improve their future performance". The objective of this research is to help learners achieve academic reading and writing ability. The course is intended for students whose starting English level is intermediate and upper-intermediate, who have some vocabulary of English, but not much practice in using it. The tutoring strategy used is to give the reader insight into his or her implicit or explicit learning strategies. The methodology applied is the communicative teaching approach, allowing communication and interaction between student and tutoring system, via agents. The interactive reading strategies applied and yet to apply include bottom-up theory, top-down theory, and schemata theory. The topics and stories used are mainly passages from textbooks, journals, reference works, conference proceedings, and academic papers, in other words, real-life academic products.

3 System features and modules

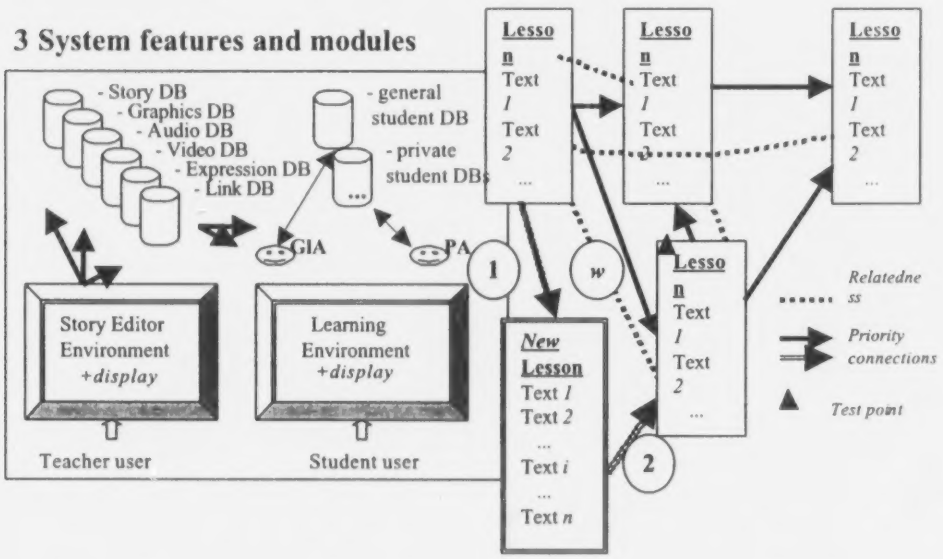

Fig. 1: The system modules and their interaction

Fig. 2: The subject link database

The system offers two interfaces, one for the teacher/tutor user, for course-authoring purposes, and the other one for the student user, who is supposed to learn. The information exchange from tutor to system contains input of lessons, texts, links between them, etc., but also asking for help in editing. The data from the tutor is stored in six different structured databases, including a library of expressions that appear in the text, a VOD database, a background image database, an audio database of listening examples, a full text database and a link database. The information exchange with the student is more complex. It contains usage of the presented materials, implicit or explicit advice, the student's advice requests, queries, searches, gathering of data on the student by the two agents, the Global Agent (GIA) and the Personal Agent (PA). Each of these agents has its own database on the student(s). The GIA stores general features on students, and the PA stores the private features of each student. User modeling follows many patterns, and has many applications. [7] proposes a fuzzy-based, stereotype collecting user model for hypermedia navigation. [18] elaborates on the Human Plausible Theory. ([4]) provides intelligent help for determining the cause of errors in software usage.

[14] has shown how prior belief (belief bias) can influence the correctness of judgment of the human (users). Other authors, like [10] have studied the relation between achievement goals, study strategies and exam performance. A realistic user model has to take into consideration the influences a system can achieve on the user, in order to allow an easy interpretation of the current state, as well as an easy and clear implementation of the user model.

4 The Authoring System Module (Story Editor)

Our most important goal is to design a meaningful, evolutionary feedback for the user. In order to build such a
system, an authoring tool is necessary for flexibility purposes: our colleagues researching the optimal material for academic English teaching should be able to add or delete freely the available resources. In a way, they are also clients/users, and should be restricted to build a courseware, which conforms to the capabilities of the system. In the following, these restrictions and their purposes are explained. These restrictions are necessary instruments for the two system agents to work with, as will be shown later in this paper.

Texts: Each video/audio recording has to have a corresponding TEXT (of dialog, etc.). For each text, it is analyzed if video is necessary, or if audio suffices, as audio requires less memory space and allows a more compact storage and a speedy retrieval. Each TEXT also has (beside of main text, etc.), the following attributes: a short title, keywords, explanation, patterns to learn, conclusion, and finally, exercises. Titles and keywords are naturally used for search and retrieval, but the explanation and conclusion files can be also used for the same purpose, as will be explained later on.

Lessons: One or more TEXTs (with video or not) make up a LESSON. Each LESSON also has (beside of texts, etc.) the following attributes: title, keywords, explanation, conclusion, combined exercises (generated automatically or not). Next, a text or a lesson will be referred as 'SUBJECT'.

Priority and Relatedness Connections: When introducing one or more subjects, the teacher has to specify the Priority Connections, i.e., to show the required learning order, with a directed graph (arrows). When there is no order, subjects will have the same priority, and build a set. The teacher (courseware author) should also add connections between related SUBJECTS, with indirect links. This means, the teacher has to add Relatedness Connections between subjects, for which no specific learning order is required, but which are related. These relations are useful, e.g., during tests: if one of the subjects is considered known, the other one should be also tested. The main differences between the priority connections and the relatedness connections is that the first ones are directional, weightless connections, whereas the latter are non-directional, weighted connections. After these priorities and links are set, the system will then automatically add more links via keyword matching, from explicit keyword files and keyword search within subjects. Priorities among the texts of a lesson are set implicitly according to the order of the texts, but can be modified, if necessary. The teacher / multimedia courseware author can decide if it is more meaningful to connect individual texts, or entire lessons, for each lesson. The way a new lesson is introduced, by asking the teacher to set at least the previous and the following lesson in the lesson priority flow, is shown in figure 2 (steps 1,2). As can be noticed from figure 2, priority connections, with no respective relatedness connection, can exist. This can happen when, e.g., common course design knowledge dictates that respective priority, but the learning contents of the lessons are quite different. These kinds of priorities are optimal student learning strategy related connections, not similar contents connections. These priorities help the system to place the current subject in the global subject map. Final priorities will be set by the system according to findings (teacher's input, keyword matching). This final result can be shown to the teacher or not, depending on the options under which the system is running. We are currently testing if it is wise to allow the teacher to have add/modify/delete rights. The final graph is used for the student, and it can be shown to the student upon request, serving as a map guide.

Numbering: SUBJECTS are numbered automatically in the order of their creation. Teachers are prohibited to use numbering. This is because otherwise, every time new material is brought, the numbering should be changed according to the new order of priorities. TEXTs are automatically numbered inside a lesson, and are referred from outside with two numbers: the LESSON number and the text number.

Test Points: The teacher should mark TEST POINTS (figure 2), at which it is necessary to pass a test in order to proceed (these tests can be at any SUBJECT level).

5 Student models and agents

The system gradually builds two evolutionary student models: a global student model (GS) and an individual student model (IS), managed by two intelligent agents: the personal agent (PA) and the global agent (GlA).

The reason for doing so is that some features, which are common to all students, can be captured in the GS. However, many studies have shown [17] that personalized environments and especially, personalized tutors, have a better chance of transferring the knowledge information from tutor to student. This is true even in the more general sense of a tutor and student, where the tutor can be man or machine, and the student likewise. In this work, we mean by agent a "computer system situated in some environment", "capable of autonomous action", "in the sense that the system should be able to act without the direct intervention of humans", "and should have control over its own actions and internal state" [13]. These agents' intelligence is expressed by the fact that each agent "is capable of flexible autonomous action in order to meet its design objectives", and that it is "responsive" (it perceives its environment), "proactive" (opportunistic, goal-directed), "social" (able to interact) [13], and of an "anticipatory" nature (having a model of itself and the environment, and the capability to pre-adapt itself according to these models) [9]. Next, the raw data stored for the two student models, the GS and IS, is presented.

The GS: The GS contains the global student features: the common mistakes; favorite pages, lessons, texts, videos, audios, grading of tests' difficulty (according to how many students do each test well or not); search patterns introduced, subjects accessed afterwards: if many IS use the same order, than they are recorded in the GS.

The IS: The IS contains the personal student features: the last page accessed; grades for all tests taken, mistakes and their frequency; if the student takes the test again and succeeds, his/her last grade is deleted, but his/her previous mistakes are collected for future tests; the order of access of texts inside each lesson; order of access of lessons (this can be guide to other students: "when another student was in your situation, he/she chose..."); frequency of accessing texts/ lessons/ videos/ audios, etc. - for guidance and current state check; search patterns introduced, subjects accessed afterwards (to link patterns with new subjects that the system didn't link before).

The PA: The role of the personal agent is to manage the information gathered on the user, and to extract from this information useful user guidance material. Each step taken by the user inside the environment is stored, and compared with both what was proposed to the user, as well as with what the user was expected to do (from the PA's point of view). The differences between previous expectation and current state are exploited, in order to be used for new guidance generation. Beside of analyzing the own user and extracting knowledge from the data on him/her, the PA is able to request information from the GIA, about, for instance, what other users chose to do in a similar situation to the current one of the PA's own user. Furthermore, the PA can contact other PA's with similar profiles (after a matchmaking process), and obtain similar information as from the GIA, only with more specificity. The PA can decide to turn to another PA if the information from the GIA is insufficient for a decision about the current support method. The PA decides, every time a user enters the system, what material should be studied during that particular session, and generates a corresponding list. Therefore, the course index is dynamic, not static. To this material, the PA will add or subtract, according to the interaction with the user during the session. According to [16], the PA is therefore an interface agent ("a computer program to provide assistance to a user dealing with a particular computer application" – in this case, a learning environment). However, the PA's job description is a little wider than this, as can be seen also in the following.

The GIA: The global agent averages information from several users, to obtain a general student model. The deductions of the global agent are bound to be non-specific. The GIA is necessary, because otherwise, the system will not profit from the fact that different users interacted with the system, and each new interaction can smoothen the path for following users. The GIA is to be referred before the PA starts looking for information from other PAs, process that can be more time-consuming. Therefore, the role of the GIA is to offer to the PAs condensed information, in an easily accessible, swiftly loadable form. From this description, it is clear that the GIA is subordinate to the PA (from the student user's point of view). The GIA cannot directly contact the student user – unless the PA explicitly requests it. If the GIA considers that its intervention is required, it still has to ask for permission from the PA. In this way, the generation of confusing advice is avoided.

From the described interactions between agents and databases, and between the agents themselves, it is clear that the agents of the system work in two ways. The first way is based on the embedded rule/knowledge systems, which try to foresee, prevent and solve conflicting situations. The second way is as evolutionary, learning objects, which can adaptively change their representation of the subject space, by creating and deleting links and changing weights. A next step in the system's agents design will be focused on adaptive problem, quiz and test generation. In short, this design is made necessary by the fact that a student, after failing to pass a test, has to be presented, after some more learning is done, with a new test, of similar difficulty and contents. As it is difficult for the teachers to generate as many tests as would be necessary for such repeated situations, this task is to be passed to the system's agents. A very important task of each of the agents is also to keep the consistency of the subject link database. The agents inform the teacher(s) if some subjects form loops (determined by the priority connections set by the teacher(s)), if some subjects become inaccessible; if a teacher is not available, they make corrections by themselves, and decide from the student (s) feedback about the appropriateness of those changes.

6 Conclusions

We have proposed in this paper an Evolutionary, Web-based, Academic English Teaching Environment, called "MyEnglishTeacher". Moreover, we have described the rationale, the design and implementation and the modules of our system: an authoring environment for the teacher user(s), which is generating the lessons, and a learning environment for the student user(s). We have further on presented each of these modules in more details. The learning environment is based on two intelligent agents, interacting with each other and the student user, in order to guide the student through a new course for academic English, which is under development in our laboratory. We have also explained in which sense our agents evolve and present intelligence. Our agents build and modify student models with the help of a double graph: a non-weighted, directional priority graph, and a weighted, non-directional, relatedness graph. In addition, we have explained how, from the authoring system courseware design requirements, we enforce the generation of structured content databases, to serve as a basis to the rule/knowledge bases, which will be used and added to by the two agents. We believe that with our system we are addressing more than one current need: the need of an English tutor for academics, which should also be easily accessible – i.e., on-line –, free, adaptive and user-friendly.

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Natural Language-like Knowledge Representation for Multimedia Educational Systems

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The appropriate use of multimedia is becoming increasingly important in computer teaching systems. Not only are students stimulated by being presented with information in a variety of forms, but such an approach also more closely resembles the real world where they have to assimilate what they see and hear, abstracting out what is relevant. With the diversity and amount of multimedia material that may be present in these systems, a powerful form of knowledge representation is required to support navigation and knowledge retrieval. The (human or computer) tutor may wish to refer to document segments, to recap important points, provide feedback, give hints and so on. The student also may wish to refer to items previously seen or heard. The Flexible Structured Coding Language, FSCL, is a natural language-like, formalised description language which allows the formulation of rich yet structured sentences. These sentences are attached to segments of multimedia documents. FSCL provides an easily accessible approach for knowledge representation, precise and rich description of complex contents, correct and complete retrieval within the descriptions, and retrieval across data of different media types. FSCL can be extended to integrate ontologies, inference of knowledge and freeform querying performed by the learner.

Keywords: **Multimedia, knowledge representation**

1 Introduction

Computer-based educational systems have developed from standalone applications, using mainly text and graphics, which focused on teaching a restricted set of subjects or skills. Today's multimedia systems are often distributed across the web using a client-server approach and aim to integrate teaching material from multiple subjects areas. These systems collect feedback on the progress of the learner and attempt to provide material at the appropriate levels. An example of such a system is GENTLE [5].

Beside the technical challenges of managing such a system, a number of conceptual ones arise. One of these is knowledge representation and the related issue of knowledge retrieval. One problem with supplying a learner with a flexible learning environment is the need to provide a mechanism for locating appropriate information. This is a non-trivial task considering the vast amount of diverse material stored and the complexity of the concepts incorporated into the learning material. Another requirement is to give the learner a mechanism for questioning the system. This can be for retrieving specific material or for asking conceptual questions concerning the subject area.

To illustrate some of the requirements for a computer-based educational system, consider a small scenario. Imagine a web-based teaching module on the use of machinery. This module could consist of a number of multimedia documents: for example, a video showing an instructor demonstrating the use of the machinery, a set of images displaying various technical features of the machinery or a set of text documents explaining various procedures. These multimedia documents, annotated with appropriate knowledge representation mechanisms and generic domain knowledge, have to be stored. Based on this information a range of material could be retrieved: a segment of the video document showing the instructor demonstrating a specific task; additional information from images or text documents relating exactly to this task; the status of

the machinery at a specific position in the video inferred from the domain rules.

After a brief overview on current approaches to knowledge representation in computer-based educational systems, we consider how the Flexible Structured Coding Language, FSCL [9,11], may be applied to this problem. We will first describe FSCL in the form it is used in its original context of studies of human behaviour and then discuss the advantages of using FSCL in computer-based educational systems. We then suggest some modifications to FSCL to provide extended support for computer-based educational systems and conclude the paper by summarising the contributions this natural language-like approach to knowledge representation can give us.

2 Current approaches to knowledge representation

To access the appropriate information in a computer-based educational system, a knowledge representation scheme is necessary. This provides a meta-level description of the contents of the educational system. In this paper, we consider the format of this meta-level description, not its technical realization in a database or file system. Before we describe some common approaches to meta-level description, we want to briefly discuss why a meta-level description is necessary and why it is not possible to extract the information directly from the learning material.

The retrieval of information from documents directly has limited scope both on a technical and on a conceptual level. Technically, searching through text based documents is easy and allows for identification of keywords, phrases or sentences. Achieving the same level of retrieval for video documents is much harder. Techniques exist to automatically parse video documents to detect scene changes [8, 23] and objects [6, 17]. However, a number of problems still have to be overcome to provide sufficient access to video content [13].

Setting the technical difficulties in accessing video or audio documents aside, there are still conceptual considerations which will demand some meta-level description of content. Retrieving appropriate information from a collection of documents will, in many cases, require access to the semantics of these documents. Searching through these documents on a keyword (or object) basis is unlikely to produce satisfactory results [2]. The transition of factual ('she was smiling', a smiling face, a sunny picture) to conceptual (happiness, pleasant atmosphere) information has to be made to access the semantics of a document. This is not possible without some meta information or description of these documents.

A number of approaches are used to facilitate the access to the semantics of documents in preparation for information retrieval. Ontologies provide a modelling scheme for a specific domain creating a shared vocabulary for the description of contents [4]. Topic maps [22] create organising principles for information by defining topics, the associations of topics and the occurrence of topics in documents. Conceptual graphs [20,21] capture knowledge about a specific domain and make this knowledge accessible to deduction using first order logic.

In the analysis of data in the social sciences, a *description* approach is common. Codes or annotations, called descriptions, are attached to specific locations of multimedia documents to assist retrieval. These can contain any kind of factual or semantic descriptions of the documents' contents. Domain specific codes or freeform textual annotations are common in analysis programs like The Observer [16], Nudist [18] or its successor, NVivo [19]. All the approaches mentioned above have been proposed to overcome the technical and conceptual difficulties of accessing the information contained in multimedia documents and to facilitate the retrieval of appropriate information. In this paper, we propose the use of FSCL as a meta-level description mechanism. In the next section we introduce the main features of FSCL. We follow this by a discussion of its advantages for knowledge representation and retrieval, and indicate how FSCL can be combined with ontologies and conceptual graphs.

3 Knowledge representation using FSCL

FSCL is a natural language-like description language. It aims to combine the expressiveness and flexibility of natural language with the rigour of formalised approaches. The main components of FSCL are its *vocabulary*, *grammar* and *categories*. The vocabulary can be freely defined by the author of the teaching material. Any word can be used and the vocabulary can be extended at any point of time. Whereas the vocabulary is likely to be defined for a specific domain, the grammar is generic. It is designed to formulate 'subject - verb - object' and 'concept - object' sentences and combinations of these elements, including

conjunctions, prepositions, adjectives and adverbs. The role of the categories is to bridge the vocabulary and the generic grammar. The grammar is defined on the categories. Each word of the vocabulary has to belong to exactly one category. This construct allows for the structure of the description language to stay the same across applications in different domains. The categories of FSCL have been defined in accordance with the word classes of the English language. The categories are: Person/Thing, Activity, Concept, Conjunction, Preposition and Descriptor (which combines the word classes adjective and adverb).

FSCL has been incorporated into an information system to support the analysis of multimedia documents, called PAC [12]. Sentences formulated with FSCL can be, in a system like PAC, attached to a segment of a multimedia document. The sentences, together with document identifiers and segment specifications are stored in a database and later used for retrieval. Because the structure of the FSCL sentences is well known, it is possible to access the semantics of the information stored. The retrieval of information from FSCL descriptions is achieved using the Flexible Structured Query Language, FSQL [9].

FSQL provides three layers for querying: the first layer is based on the properties of FSCL and allows the correct and complete retrieval of information from the description sentences; the second layer provides for Boolean combinations within sets of description sentences; the third layer accesses the properties of the multimedia document segments attached to the FSCL sentences and facilitates time and position comparisons. More detailed information on FSCL and FSQL can be found in [9]. Specific information about information retrieval across multiple media formats is given in [10].

4 Advantages of using FSCL

The most convenient and expressive language available to us is natural language. Yet looking at knowledge retrieval with computer systems, natural language poses a range of well known and not yet fully solved problems. The main problem lies in the vast amount of implicit knowledge necessary to see words in the right context and to fully understand a sentence [21]. Various large scale projects are underway to attack these problems, like WordNet [15], an ontology for natural language processing, and the Cyc system [14], attempting to construct a 'complete' ontology of the world. Our approach is far less ambitious. We acknowledge that using full natural language for knowledge representation and retrieval would be highly desirable. Yet with the enormous difficulties associated with this approach we were looking for a much simpler solution. FSCL provides us with a number of advantages:

- We have a natural language-like notation. Any FSCL sentence can immediately be understood by a human reader. The importance of this is confirmed in the discussion of the five principles of knowledge representation by Davis *et al* [3].
- We have a language and can deduce the structure of our sentences. We have therefore more power than with the keyword approach commonly used in information retrieval, which suffers from low precision and low recall [21].
- We can build a powerful vocabulary by integrating the FSCL categories with ontologies.
- Of special interest to computer-based educational systems is that we can link our form of knowledge representation with multimedia documents.

FSCL has been successfully used to support the study of behaviour recorded in multimedia documents. It has given analysts the possibility to create rich descriptions of behaviour and to analyse the descriptions in a precise way [9]. We want to keep the main features of FSCL in formulating natural language-like, structured and flexible sentences attached to multimedia documents. Further, we want to adapt FSCL for a more general use in knowledge representation and retrieval. Our ideas in this direction are presented in the next sections of this paper.

5 Proposed extensions

We want to indicate several areas of possible changes and extensions to FSCL: changes to its categories and grammar forms; extensions to include ontologies; conversion of FSCL sentences to conceptual graphs to facilitate inferencing; and the introduction of freeform querying.

5.1 Changes to categories and grammar of FSCL

As described in section 3, the FSCL categories and grammar have been designed to formulate sentences of the forms 'subject - verb - object' and 'concept - object' in the context of studies of behaviour. To simplify the construction of the vocabulary, adjectives and adverbs have been combined in the FSCL category 'Descriptor' [9]. Adhering to the general FSCL principle of having a formal grammar on fixed, defined categories we are currently investigating a number of changes to FSCL to adapt it to a more general use in knowledge representation. The exact format of the changes has to be determined through applying FSCL in a range of web-based educational systems. Our current thinking centres around the following topics:

- We are investigating changes to the FSCL categories. Merging the categories Person/Thing and Concepts to a more general category, Noun, would address the potential conflict between abstract and concrete terms (see the discussion about the abstract term 'students' and the specific individuals in section 5.3). The category 'Descriptor' could be split up into separate categories of 'Adjectives' and 'Adverbs'. The grammar of FSCL had to change accordingly to accommodate the different roles of adjectives and adverbs within a sentence. The advantage over the current approach in FSCL would be that with this change adverbs could be positioned correctly as in natural language English sentences.

- In natural language, words occur in different grammatical forms in different roles in a sentence ('the instructor *starts* the motor'; 'the motor is *started*'). The current FSCL has a strict separation between its categories. While a word can be defined in its derivations in multiple categories (Activity: starts; Descriptor: started), it is not possible to create a semantic link between the different word forms. We are looking at introducing such a link together with a meta-level grammar to be able to detect semantic equivalence between sentences with word derivatives in different parts of speech.

- The grammar of FSCL could be extended to recognise a wider range of sentence structures. Clausal variations like imperatives ('Start the motor!') or questions ('Is the motor running?') can be introduced. Conditional sentences of the form 'if C then S' would support inference as outlined in more detail in the following section. A wider range of sentence structures recognised correctly by FSCL would increase the potential for knowledge retrieval and inference.

5.2 Extension to use ontologies

FSCL uses hierarchies to define the words of the vocabulary. These hierarchies are defined within the FSCL categories. They are used to group related words and to allow for a retrieval of information on different levels of granularity. These hierarchies, as they are currently used in FSCL, can be seen as simple forms of ontologies. While a number of issues have to be addressed to base FSCL on more substantial ontologies, none of these seems to pose a real problem.

- Users of FSCL define the vocabulary they need for their particular domain. The experience, so far, as reported in [9], show that users define their vocabulary as multiple hierarchies within each FSCL category. These hierarchies could be joined under the FSCL category name to build one ontology within each FSCL category.

- An ontology typically moves from the abstract to the concrete, from concepts to instances. The vocabulary in FSCL is organised in the same way. In a study on 'learning to read', e.g., individual students' names were grouped under the term 'students', individual teachers' names under the term 'teachers' [9]. A term like 'students' contains two components: it has an abstract component in describing a group of the population in general with the property of 'attending school to learn'; it has a concrete component in grouping together specific, named individuals. In the current uses of FSCL this distinction has not caused any problems.

- Not all FSCL categories contain vocabulary which necessarily should be structured as ontologies. While it can be of advantage to organise the vocabulary in the FSCL categories 'Conjunction' and 'Preposition' in hierarchies these words will not build ontologies as they not define 'categories of the world'. Yet the coexistence of ontologies and hierarchies in the vocabulary of FSCL should not create a difficulty.

5.3 Conceptual graphs and inference

FSCL is an easy to understand and effective scheme for an author to create their own vocabulary and use it

together with the grammar for describing the contents of a multimedia document such as a video. Currently, knowledge retrieval is performed using the complementary query language FSQL. FSQL addresses the grammatical structure of FSCL sentences, takes advantage of the hierarchy information built into the vocabulary, and offers Boolean, time and sequence query options. However, there is no deductive feature in this scheme which would allow us to be able to infer facts or relations that are not explicitly stated. For example, given the statements:

If anyone starts the motor then the motor is running
The instructor starts the motor

which describes the situation in a training video then we may wish to be able to answer the question:

Is the motor running?

To be able to function at this level, we need the power of a first order logic system. Conceptual Graphs, CG, [20] give us this power.

Our proposal is that the user should describe their domain in terms of FSCL. The statements in this language can then be automatically translated into a CG format. This process is quite straight forward since FSCL is unambiguous, allowing many of the problems of natural language translation to be circumvented.

When a query is made, or some information needs to be located within the document segment then an initial attempt can be made to do this by using FSQL. If this fails then the deductive power of the CG representation is invoked. Standard theorem proving techniques within CG would enable us to check the veracity of a statement. As a bonus, we would get a step-by-step justification of the result proved, similar to the explanation given in expert systems.

5.4 Freeform Querying

Based on a limited yet flexible vocabulary and on a limited grammar, as offered by FSCL and FSQL, a query system can be developed which allows the user to pose questions to the educational system. As the structure and the vocabulary of these questions is known, the educational system can 'understand' these questions. Questions can be mapped against a repository of previously asked questions. If a semantically equivalent question is stored, the corresponding answer is retrieved and presented to the user. If a semantically close question is stored, this previously asked question can be used to facilitate the answering of the new question. As questions and knowledge representation are constructed by the same underlying mechanisms a mapping from question to knowledge representation is possible. This can be used to assist the answering of questions based on the knowledge descriptions and to find the appropriate segments of the multimedia teaching material.

The approach presented here does not attempt to answer any natural language question but a restricted set. The vocabulary is restricted to allow the construction of meaningful questions in a particular domain. The grammar is restricted to allow the construction and comparison of meaningful questions based on the vocabulary. The grammar is generic as it is based on categories which are used to organise the vocabulary across domains. The restriction of vocabulary and grammar distinguishes this approach from the AskJeeves [1] search mechanism. The existence of a grammar distinguishes this approach from keyword based search mechanisms as used in library systems or by internet search machines.

The general idea is to provide the user with specific answers to questions. These answers are retrieved from a body of stored answers only if semantic equivalence can be guaranteed. If semantic closeness is detected the relevant questions with their answers are given to a human operator who then decides on the suitability of the match.

6 Conclusions

In this paper we have considered the need for a knowledge representation mechanism for computer-based educational systems. We have first indicated a number of commonly used mechanisms and have then discussed the Flexible Structured Coding Language, FSCL. We have suggested that FSCL provides an effective mechanism for knowledge representation and subsequent knowledge retrieval, based on the nature of FSCL as a natural language-like description language which allows for flexible, rich yet structured description of learning concepts. As extensions to FSCL we have suggested the integration of more substantial ontologies, the conversion of FSCL sentences into conceptual graph structures and the introduction of freeform querying.

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On Supporting Semantic Indexing in a Mediabase System which Facilitates Collaborative Learning

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Our mediabase system "ShareMedia" can facilitates collaborative learning, especially, inductive knowledge acquisition. In ShareMedia, learners in a community add, collaboratively, structured query to the electric data, which is to be registered in the mediabase. Structured queries consist of query units. Pieces of electric data express concrete knowledge or cases. Then they can navigate and retrieve pieces of electric data express by use of the queries. In other words, they can compare and examine the pieces of electric data and know their relationships. Consequently, they can acquire knowledge inductively. However, it is difficult for them to select suitable query units for a structured query. In this study, then we applied Latent Semantic Indexing to the supporting method. In our method, pieces of electric data and query units are represented as a vector space. The vectors are decomposed by Singular Value Decomposition, and then new vectors will be created. The piece of electric data that a learner wants to index is also processed with the same method. Then, the new electric data vector is compared with the new query unit vectors, and suitable query units will be selected. As a result of evaluation, our supporting method was proved to perform well.

Keywords: **indexing, navigation, collaboration, hypermedia, mediabase**

1 Introduction

In the field of education, teachers and researchers are, recently, more concerned about collaboration. Because of it, Many Computer systems are developed to support collaborative learning. For example, CSILE[1,2] facilitates knowledge building in a community, Collaboratory NoteBook[3] supports scientific inquiry activities in high school.

The mediabase system "ShareMedia[4,5]", which we are developing now, is such a system that supports learner's activities of description and accumulation, sharing, searching, selection of knowledge. In detail, it can not only promote the process of learner's browsing accumulated cases or knowledge and discovering their relationships, but also train their skills to share and use such cases and information in a community. Though we now assume that learners in high school geography class use ShareMedia, of course ShareMedia can be used in another domain.

ShareMedia needs not to link between nodes explicitly, and requires only indexing retrieval indices to media representations (see chapter 2). Then, ShareMedia enables learners to retrieve flexibly based on the semantics or concept of data by use of retrieval indices. Through the functions mentioned above, ShareMedia facilitates collaborative learning in a junior high school geography class to acquire generalized knowledge from individual cases and knowledge inductively and to index semantic indices to them in order to enable such activities.
ShareMedia supports learning activities as follows:

1) In a small community (e.g. a classroom or a group), learners collect electric media as individual knowledge or concrete cases and add indices express their concept to them. Then, learners store their shared mediabase with the electric media.

2) The learners browse the shared knowledge and compare pieces of the knowledge, which are extracted with indices, many times. As a result of this activity, the learners can abstract the pieces of the concrete knowledge and understand the relationships between them.

3) The learners discover inductively generalities or rules, which exist in the relationships, and deal with them as hypothesis.

4) The learners apply deductively the hypothesis to pieces of individual knowledge and can acquire then as generalized knowledge if their propriety is confirmed.

2 Mediabase system "ShareMedia"

The current version of ShareMedia (Fig.1) was developed on UNIX environment (Solaris CDE ver.1.3) with JAVA Development Kit ver.1.1.7 and K-Prolog Compiler ver.4.0. ShareMedia consists of several components. Above all, media representations, semantic frames, semantic indices and retrieval requests are important. Their details are as follows:

2.1 Media representation

Media representations (Fig.1.a) are electric data of pieces of individual knowledge or concrete cases. They are represent as texts, images, pictures, movies, sounds and so on. In this paper, however, only text form is dealt with because of presumption of semantic frames with natural language processing. Learners index a semantic index mentioned below to the block of a media representation and store the shared mediabase of ShareMedia with the media representation. After storing, learners can chose media representations from the list of them. With semantic indices, however, learners can navigate them more flexibly.

2.2 Semantic frame

Semantic frames (Fig.1.b) are used as query units and are primitive units of concept or semantics of media representations. They have slots that express subject, object, means, moment and so on. For example, "utilize" frame has "who", "what" and "to what" slots and "be factor" frame has "what" and "of what" slots. Learners should decide their form by mutual agreement in order to use them effectively in learning activities and store shared mediabase with them consistently.

2.3 Semantic Index

Semantic indices (Fig.1.c) are structured queries to express concept or semantics of media representations. Learners select semantic frames that are suitable to a media representation, which the learners will store mediabase with. Then, the learners combine them and link their relative slots. Like this, semantic indices are created by combining semantic frames and are indexed to media representations. They are used when learners retrieve or navigate media representations.

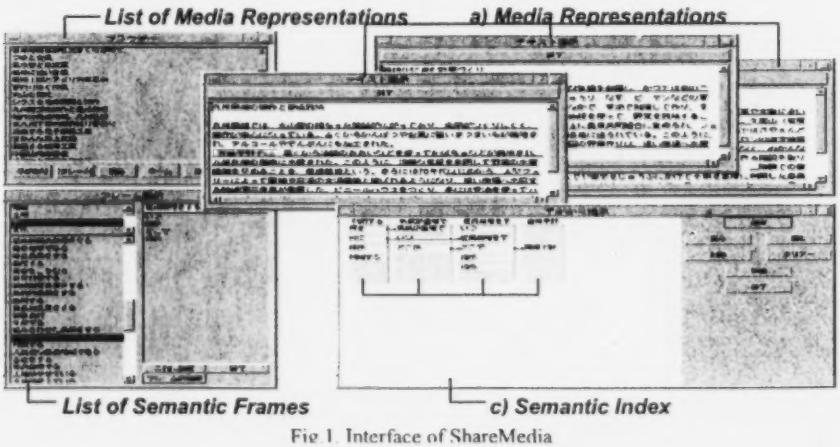

Fig.1. Interface of ShareMedia

2.4 Retrieval request

Retrieval request is used when learners retrieve or navigate media representations that are stored in shared mediabase. A learner creates it in the same way as semantic indices. Then, the learner submit it to ShareMedia, he will be presented media representations, which were indexed semantic indices that match the retrieval request. Owing to semantic indices and retrieval requests, learners can retrieve and navigate semantically.

These components mentioned above can facilitate learner's activities to navigate pieces of knowledge semantically, to understand their relationships inductively and to discover generalities, which exist in them, deductively. However, it is difficult for learners to select suitable semantic frames for a semantic index or a retrieval request.

3 Supporting learner's selection of semantic frames

In this study, we applied LSI[6] (Latent Semantic Indexing) to the supporting method for selecting semantic frames. Because LSI is one of statistical method, similarity of documents can be presumed without any dictionaries. In LSI, documents are dealt with a term by document matrix. Then, rows of it can be considered to be term vectors and columns to be document vectors. In addition, these vectors are decomposed by SVD (Singular Value Decomposition), as a result, terms and documents are abstracted.

In our method, media representations and semantic frames are represented as a vector space model. In training, the vectors are decomposed by SVD, and then new vectors will be created. In presumption, The media representation that a learner wants to index is also processed with the same method. Then, the new media representation vector is compared with the new semantic frame, and suitable semantic frames will be selected. Their details are as follows:

3.1 Training

Training needs a data set, which is a collection of combinations of paragraph and semantic frames. Here, paragraph is a part of media representation and contains one or more blocks, which are indexed parts of the media representation. And semantic frames are contained in the semantic indices, which were indexed to the blocks. First, Paragraphs are done morphological analysis with Chasen, which is one of Japanese morphological analysis tool. As a result, word lists of each paragraph are created.

Next, they are filtered in order to extract only the words, which have noun, verbal, and adjective morph. After filtering, they are sorted by frequent descending order. Based on them, a sorted list of all words is generated. On the other hand, based on the relation between the word lists and the semantic frames, sorted word lists of each paragraph collection, which relate each semantic frame, are created.

Then, word by semantic frame matrix is computed from these two type lists. This matrix can be divided to word vectors and semantic frame vectors. SVD decomposes them and creates new word vectors, new semantic frame vectors and the diagonal matrix of singular values. These vectors and matrix are used in presumption.

In addition, latent relationships will be available in presumption, because this decomposition abstracts the words and the semantic frames

3.2 Presumption

To presume the semantic frames that are suitable to a whole media representation or a block of it, the vector of these text strings is processed with new word vectors and diagonal matrix, which are created in training. As a result, new text vector is created. It is compared with each new semantic frame vector by computing cosine between them. The more cosine value is large, the more the semantic frame that corresponds to the new semantic frame vector is suitable to the text string. Then, a list of semantic frames, which are arranged by descending order of cosine values, is made. This list will support learners to select semantic frames, which is suitable to a media representation.

4 Experiment

4.1 Training data set

We prepared 304 media representations, 318 semantic frames and 318 blocks, which were indexed semantic indices by manual. A block, we call in here, is a part of a paragraph where semantic indices are indexed. A media representation contains one or more paragraphs. A block might extend through several paragraphs. Though media indices are indexed to blocks, we use paragraphs to training because of giving redundancy to the presumption. Media representations and semantic frames used in here were extracted from the Japanese geography area of Japanese junior high school geography textbooks. By making use of this data set, new word vectors, new semantic frame vectors and diagonal matrix were computed.

4.2 Evaluation

We use 93 blocks, which are used in training and chosen at random, in order to evaluate the presumption of our method. Each media indices, which were indexed to the blocks, have 3.63 semantic frames on the average. The method presumed suitability of each one of 318 semantic frames to each one of 93 blocks by computing cosine values

4.3 Result

We confirmed their propriety about top of 5, 10 and 15 semantic frames, which were arranged by descending order of presumed suitability to each one of 93 blocks (see, Table 1). In Table 1, "Suitable to Blocks" indicates the average number of frames which experimenter judged suitable to each block. In the same way, "Suitable to Paragraphs" indicates the average number of frames to each paragraph. "Indexed by Manual" indicates the average number of frames, which are indexed to each block by manual beforehand.

Table 1. Average numbers of semantic frames which experimenter judged suitable.

	Suitable to Blocks		**Suitable to Paragraphs**		**Indexed by manual**	
Top	average	precision	average	precision	average	recall
5	2.10	42.0%	2.78	55.6%	1.81	49.9%
10	3.13	31.3%	4.39	43.9%	2.44	67.2%
15	3.72	24.8%	5.32	35.5%	2.77	76.3%

4.4 Discussion

A glance at Table 1 will reveal that presumption of our method is good. For example, seeing top 10 row, the precision within the range of blocks is 31.3%, the precision within the range of paragraphs is 43.9% and recall is 67.2%. Take it into consideration, our method can extract many of semantic frames which should be indexed. In short, learners can easily extract many of necessary semantic frames by selecting from them, which our method presented.

To illustrate the performance more precise, however, we need to make another experiment, because this experiment used same data in both training and evaluation.

5 Conclusion

In this paper, we described the process that ShareMedia supports learning activities, abstract of main components of ShareMedia, our supporting method for learner's selection of semantic frames and it's performance. As a result of the experiment, our method proved to perform well. To judge the performance of our method more strictly, however, we need another experiment with data sets that differ in training and evaluation. And we will improve our supporting method based on the result of it.

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SimPCS: A Web-based PCS Learning Tool

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With rapidly growing interest in the area of wireless communications in recent years, the wireless resource allocation problem has received tremendous attention. The demand has led to intensive research and studying efforts for personal communication systems (PCS). Many related courses have been offered and corresponding web-sites were developed. Unfortunately, most of the web-sites contained only static and pre-defined PCS information. The utilization of wireless resources is determined by many complex factors such as geography, the distribution of mobile subscribers, and the communication congestion. It is difficult to understand the characteristics of PCS by using only the conventional education materials. This work designs, develops, and implements a web-based PCS learning tool that meets the above criteria. The system provides the merits of personality, transparency, efficiency, scalability, portability, and flexibility. It offers simulation and data analysis so that the user can learn actively and understand easily the advanced issues of PCS.

Keywords: **Web-based learning, PCS, simulation, performance visualization**

1 Introduction

Computer-assisted instruction (CAI) programs based on Internet techniques, especially on the WWW, provide new opportunities in various applications. Due to the reason that the growing popularity of the World Wide Web, the characteristic of its portability, wide acceptance, and comprehensive availability can help us to solve many problems related to conventional CAI systems, which lack portability and local availability.

A PCS system is a wireless network that provides communication service with mobility to its subscribers. With rapidly growing interest in the area of wireless communications in recent years, many related courses (e.g., wireless communications, mobile computing, personal communication systems, etc.) have been offered and corresponding web-sites were developed. However, most of the web-sites contain only static and pre-defined information of PCS. Few web-based PCS learning tools have been developed to provide a highly interactive facility for users.

The wireless resource allocation problem has received tremendous attention in the last few years and the demand has led to intensive research and studying efforts for the related topics. Unfortunately, the utilization of wireless resources is determined by many complex factors such as geography, the distribution of mobile subscribers, and the communication congestion. It is difficult to understand the characteristics of PCS systems by using only the conventional education materials. Simulators can be used to identify various characteristics of PCS systems and to support decisions and understanding by giving the possibility of experimenting with different scenarios [24].

However, the simulation of a PCS scenario is time consuming for large-scale PCS systems. Therefore, scalability is an essential factor for the simulation of PCS systems. As well known, conventional sequential simulation techniques can not adequately fulfill such simulation requirements, necessitating the development of parallel simulation techniques capable of doing so. On the other hand, when very great amount of users use the simulation system at the same time, the load of the server will be quite heavy so that the performance decreases rapidly and the response time of a simulation experiment increases.

It is essential that a learning system should be capable of providing the flexibility of usage profiles and services for different users. Users can be classified according to the conditions of user's ability, frequency, and so on. It is expected that each user may have an adaptive interface and configuration to fit his/her requirement. Furthermore, in order to improve the performance of a simulation system, the technologies of parallel processing and caching should be applied. The user may reuse previous simulated results without doing a long-running simulation experiment again, thereby reducing the waste of computation resources of application servers. It not only reduces the waste of the computation resource but also provides real-time services for users.

In light of above discussions, we develop SimPCS, a web-based learning tool for PCS which integrates simulation and computing in a multimedia learner environment with various enhanced functionalities. The proposed system has the merits of personality, transparency, efficiency, scalability, portability, and flexibility. The system can be used to help users to understand the concepts of PCS systems. By using the PCS simulation and data analysis, the users can understand the advanced issues of PCS environments (e.g. resource allocation, probability of blocking call, etc.).

The rest of this paper is organized as follows. Section 2 discusses the architecture of conventional CAI systems and related technologies applied to our system. Section 3 describes the proposed system architecture. The implementation of our system and a prototype are illustrated in Section 4. Section 5 discusses the usage profiles and case studies. Finally, conclusions are offered in Section 6.

2 Related Work

In recent years, training environments based on computational simulation are being used much more frequently and the importance of simulators is widely appreciated. They are used to support decisions and understanding by giving the possibility of experimenting with different scenarios. For a training environment, one thing that is commonly assumed is that the trainee has a reasonable amount of knowledge about the subjacent model and is capable of analyzing and learning from the simulation results [4]. From a user's aspect, the tools must have characteristics of convenience, auto-analytic, assistant, resource sharing and so on [10,18,20]. The rationale behind the use of multimedia in education is that some media transmit certain kinds of information better than others. This makes it possible to give media an extremely important role in the context of education and learning [6]. The motivation for the use of simulation in an education is that it supports an active learning approach and maximizes the learner control [18]. The degree of available learner control defines the perceived level of interactivity of a course [19]. Learner control is seen as the control over learning strategy, manipulation of learning content and description of content [14]. The claims are that an active learning approach facilitates learning. Learners appear to be more engaged and have better motivations. Simulation enables learners to make their own errors, try to find these out, explore these and learn from these. Moreover, simulators are powerful in situations in which they otherwise would be difficult or impossible to give training or education. It is realized that simulation needs to be embedded in an instructional environment to fulfill an instructive role in a satisfactory manner [23].

In this way the content of a conventional CAI program, which is necessarily limited, can be strongly expanded. Web-based CAI programs differ from conventional CAI software [8,12-13,17,21] significantly and therefore require a specific consideration. It can be utilized on almost all of computer platforms. The materials of CAI systems can be shared since WWW is based on the network technologies. The learners can be free from restrictions of space or time. Conventional CAI programs can be stored on data media, installed, and used on stand-alone computers [1]. By contrast, WBT (web-based training) programs are based on Internet technology, in particular on WWW technologies. Generally, CAI programs can be subdivided into three layers: presentation, teaching, and domain data and knowledge. These combinations generate different types of architectures [6].

Many efforts have been made to improve the limitations of wireless communications [9,11]. In order to increase the system capacity, many advanced channel allocation schemes were proposed [13,21]. Another way to increase the system capacity is to split the cell into micro-cells. The micro-cell architecture is an efficient way to increase the total available channels but additional infrastructures are needed [21]. Many simulation languages and tools have been developed for the simulation of large-scale networks such as cellular mobile systems. Parsec, a parallel simulation language, can be used to develop simulations for complex systems and mobile wireless networks [16,22]. Other systems were developed that can simulate large-scale cellular mobile systems [2]. They used discrete event scheme to model cellular mobile systems

and proposed the synchronization schemes to avoid faults distributed computing environments. Lin [15] proposed a PCS handoff simulator that supports arbitrary PCS cell structure and can be used to evaluate the call blocking probability or forced termination probability.

3 System Architecture

In this section, we describe an overview of our system architecture and the functionality of each component. Figure 1 illustrates the system architecture layout from three different viewpoints, the interaction type, distributed teaching program, and system configuration. For the interaction type, the system provides methods of presentation, browsing, and simulation. The user can interact with the system through various interaction types. For the distributed teaching program, it describes the architecture of client-server and layers for distributed teaching. For the system configuration, it describes the detailed modules of the system.

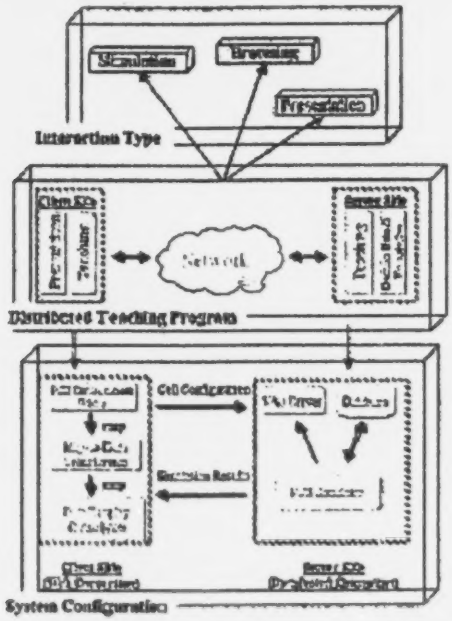

Fig. 1 System architecture

3.1 Interaction Type

SimPCS provides three interaction types including browsing, simulation, and presentation. The details of each interaction type are described as follows.

(1) Browsing:

Here, the user can determine the contents and the consequences of the presentation by accessing the contents through freely navigable hypertext. Internet users can browse the system through a Java-enabled GUI (graphical user interface). In order to reduce the response time of simulation, the caching mechanism is applied, which allows the user to quickly obtain the simulation results and without wasting the computational resources of the application server. Moreover, it provides basic functions to support analysis and display of performance information. The user can determine the contents and the consequences of the presentation by accessing the contents through borrowing.

(2) Simulation:

In the simulation system, the user can easily construct a PCS environment. Then, the user can assign the parameters related to the PCS environment. Next, the parameters are embedded to our parallelized simulation system. Finally, users can use visualization functions to analyze the characteristics and observe the performance variation of different factors. In addition, the system provides various virtual objects to let the user simulate a real environment. On the other hand, the techniques of parallel processing and caching are applied to the system to improve the efficiency of the system.

(3) Presentation:

In this case, the system presents the information in a linear manner just like slide show. The system provides static education materials such as slides, notes, simulation results, and other related information. The system can also be used to support distance learning of PCS environments.

3.2 Distributed Teaching Program

The distributed teaching architecture offers the best performance and the least network traffic of all web-based training architectures. The system we provide belongs to this architecture. On the client side, the presentation layer constitutes the interface between the user and the teaching layer. It is responsible for the presentation and management of usage profiles. It provides the flexibility of usage profiles and services for different level of users. The teaching layer handles user activities (mouse actions, inputs and so on), and then responses to the presentation layer. It is implemented in our system with JAVA programming language to process user activities. On the server side, the teaching layer is responsible for the simulation of PCS systems and processes queries. In order to improve the performance of simulation, the techniques of parallel processing and caching are applied. In the domain data and knowledge layer, the simulation data is saved in a database. It has considerable advantages: multi-stage queries to the data and knowledge layer can be completely created and executed on the server.

3.3 System Configuration

The system configuration consists of many modules. On the client side, the user can use any Java enabled browser. Internet users can communicate with the system through the GUI. The server side provides the ability of the simulation. The PCS environment construction system is used to minic a PCS environment. After constructing an environment, a map representing the environment is transferred to cell configurations. The cell configurations are sent to the PCS simulator and the map is sent to the performance data analyzer. The PCS simulator is used to simulate the behaviors of mobile hosts on the constructed PCS environment. After the simulation, the results are sent to the performance data analyzer/display. Then, the system analyzes the performance data and visually displays it on the map. The database server stores cell information and simulation results obtained from the application server.

The client side is java-based interface. It can enable the users access the system through a WWW browser. The client side consists of a PCS environment constructor and a performance data analyzer. The PCS environment constructor consists of a PCS environment editing module and a map-to-data transformer module. Their features are listed as follows:

(1) **PCS Environment Editor:** the PCS environment construction system is an iconic editor. It provides many iconic objects to represent different things such as a station, highway, or city. With these objects, the user can set up different parameters to change the cell configuration. For instance, the user can set up a station or a city in a cell and the system will automatically change the parameters of the cell such as the number of MHs and call arrival rate. This mechanism makes the simulator more practical.

(2) **Map-to-Data Transformer:** the transformer is used to transfer the map (constructed by PCS environment construction system) to readable parameters for the simulator.

On the server side, the simulation system consists of three components: a Web server, a database server and an application server. The Web server is in charge of communication with the client and manages the application server. The database server stores cell information and simulation results obtained from the application server. Because the database server provides a caching mechanism, the user may replay the

simulation results without wasting the execution resource of the application server. Therefore, simulation is more efficient. The application server is responsible for the execution of the PCS simulator. The application server can be a distributed computing environment (i.e. a network of workstations or a supercomputer). The PCS simulator on the application server can simulate large cellular mobile systems more efficiently with these powerful platforms.

The PCS simulator is used to simulate the behaviors of MHs on a specific PCS environment. The basic behavior of a base station (BS) is to provide channel allocation service and communication service for mobile hosts (MHs) within its service range (cell). The BS chooses a channel to serve when a MH needs a communication. If no channel is available, either a channel is borrowed from neighboring cells or call blocking occurs. For details, we refer readers to [5].

The client side and the server side can be used independently or together. This will facilitate other PCS simulators to embed to our system. Users can use the PCS environment constructor to construct a simulation environment. Then, they can use performance analysis/visualization tools to analyze results.

4 Implementation and Prototype

In this section, the classification of the system modules is discussed. SimPCS can be used to help instructors to create motivating lectures and allow the students to do experiments so they can understand relative wireless information in depth. Users may compose and simulate a PCS environment using various modules. Figure 2 illustrates the hierarchical relation of these modules.

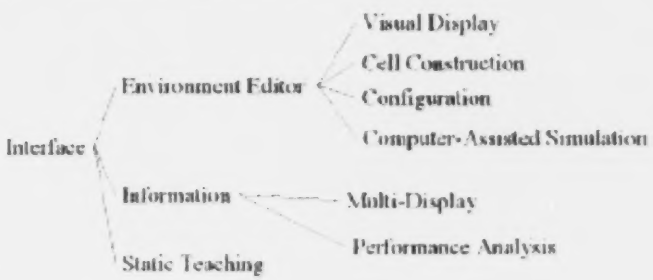

Fig. 2 The hierarchy of modules

(1) Interface module, is the front-end object for SimPCS. It offers the basic functionality required for an interactive program. Its main types of the widgets used to make a control are the pull-down menus and panels, which have the basic file operations and customization at this level. Figure 3 is a snapshot of our system. This layer is the root of all modules of our system. It consists of the environment editor, the information modules, and the static teaching module.

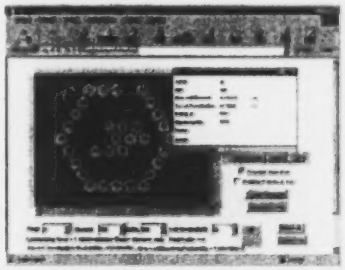

Fig. 3 A snapshot of the system

(2) **Environment editor module**: provides the establishment of a virtual environment. It enables the user to compose and establish complex conditions with virtual objects (e.g., house, river and road), to import and edit a map and save an established map.

(3) **Visual display module**: is an advanced feature of the system. It provides many iconic objects such as a station, highway, or city. With these objects, users can construct a mimic PCS environment. It enables users to simulate a PCS environment. Within the environment, the user can set up different parameters to change the cell configuration.

(4) **Cell construction module**: is responsible for establishing the cells in a selected area of the map. The user can directly select the cells on the map with the mouse. The module can create cells after constructing the environment. Figure 4 shows an example of cell distribution. The module also provides a mechanism of recombination. It uses the performance visualization grains to advance the visualization capability [4]. The technique facilitates to reorganize the performance visualization grains and support various presentations. The system can merge/split the performance visualization grains for specific geographical areas or cells.

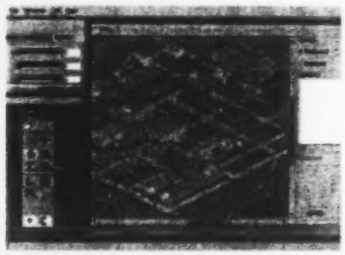

Fig. 4 Cell establishment

(5) **Configuration module**: offers the function of configuration of the objects. It allows users to set and configure the properties and limitations of the objects. The user can set call holding time and residence time of each mobile host. Figure 5 shows the dialog of configuration.

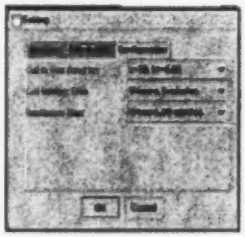

Fig. 5 Configuration

(6) **Computer-assisted simulation module**: as suggested by the name, provides the simulation of practiced conditions. It provides the user with methods to generate parameters of practiced conditions and transmit the queries and parameters form the user interface on front-end to the simulator which applies parallel/distributed computing techniques on the server. It also allows the user to choose several processors in order to run the programs simultaneously. The users can explore their behaviors after simulation.

(7) **Information module:** offers the information of simulation results, which consists of multi-display module and analysis module.

(8) **Multi-display module**: offers advanced presentation forms. It not only displays the static information (e.g. cells, channel, blocked call and so on) but also provides different presentation forms according to different configurations. Currently, two presentation modes are available to the users, color and numeric. In the color-oriented mode, the simulation results can be expressed by different colors. For instance, high blocking probability can be expressed by red color and low blocking probability can be expressed by green color. With this mode, the user can easily identify the area with high blocking probability. On the other hand, the numeric-oriented mode offers users the capability to see the details of each cell.

(9) **Performance analysis module**: provides the basic functions of performance analysis. SimPCS provides statistical analysis functions for the performance data. The main objective is to allow support the users in their efforts to understand the results and behaviors of simulation. The users can analyze the different results and behaviors of simulation according to different factors (e.g. new call blocking, forced termination). Figure 6 illustrates the different types of analysis of simulation results with histograms and pizza graphs.

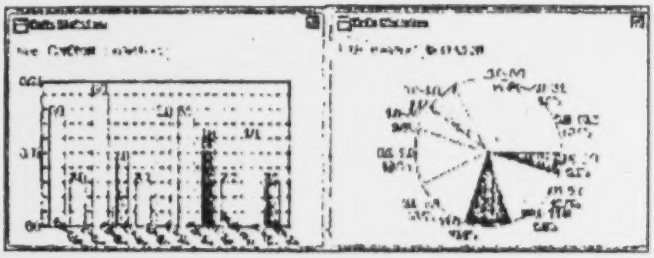

Fig. 6 Different types of analysis

(10) **Static teaching module**: is used to present static education materials. The information of PCS is presented in some manners just like slide show, notes, and simulation results.

After this brief description above, we can refer to the fact that actual prototype of SimPCS has been implemented with Java programming language in an object-oriented development environment.

5 Usage Profiles and Case Studies

This section gives different scenarios of using SimPCS for different users and discusses the services for them. Figure 3 depicts a snapshot of SimPCS for novice users. First, a novice user can select different parameter values such as number of rings(cells), number of channels in a BS, number of MHs in a cell, and the average call arrival rate of MHs. After the novice user selects the parameters, SimPCS accesses the pre-simulated (caching technique) data from the database system and presents the probabilities of new call blocking and forced termination, using the predefined PCS system model. The user can then use the visualization function to refine the presentation of the performance data. Figure 3 illustrates the snapshot of the system with statistical analysis.

The simulation system provides flexibility that means the simulator should provide different services for different users. The proposed performance visualization system classified target users into three groups: novice or first-time users, knowledgeable users, and expert frequent users. Each group will have a different usage jurisdiction. Figure 7 illustrates the relationship between users and operations.

(1) **Novice or First-Time Users** – True novice or first-time users know little of PCS systems nor do they want to understand the concept of PCS systems. These users will use a menu to select items to play with (i.e. ring of cells, number of channel, number of MHs in a cell, and call arrival rate). By choosing different the menu item and seeing the quick feedback on the screen, they will be exposed to an overview of PCS systems. The results have been stored in the caching mechanism on the database server, thereby, reducing system response time.

(2) **Knowledgeable Users** – Knowledgeable users understand concepts within PCS systems such as new call blocking, forced termination, call arrival rate, and so on. The proposed system allows knowledgeable users to execute the PCS simulation with their own parameters. These users tune the allocation of the resource by changing predefined parameters and observe the performance difference between their options.

(3) **Expert Frequent Users** – Expert "power" users are experts with the PCS systems and will develop and implement a PCS system to verify their research. The expert users will construct a PCS environment to mimic the real environment for evaluating performance. Since our prototype provide the capability to construct and mimic PCS environments, users can embed their simulation protocols into our system and use the analysis/ visualization tools to analyze the performance data.

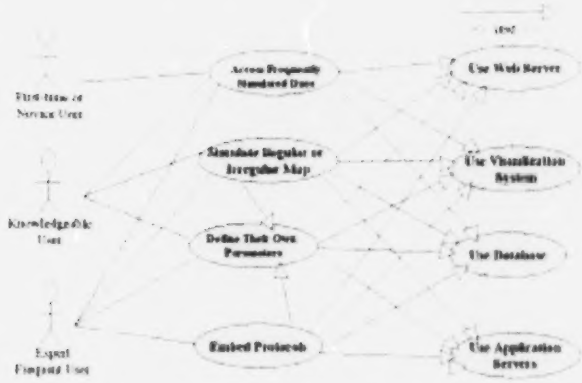

Fig. 7 Available functions for users

6 Conclusions

This work designs, develops, and implements SimPCS, a web-based PCS training and learning tool, to provide users a more flexible learning environment and give users full user-control capabilities. SimPCS can be easily used through a web browser to achieve the goal of cooperative testing and learning. It can simulate large-scale PCS systems up to thousands of cells. SimPCS has the merits of personality, transparency, efficiency, scalability, portability, and flexibility. SimPCS provides many user-directed features. It not only simplifies the complexity of programs but also supplies convenience for the users. Furthermore, the system provides the user with several editing components of the visualization system and many iconic objects to design the simulated environment by clicking the mouse directly. Although related investigations extensively perform simulation studies, relatively few web-based, large-scale PCS learning tools are developed as these models are rather time consuming. SimPCS uses the distributed teaching architecture, which offers the best performance and the least network traffic of all architectures. In addition, parallel processing and caching mechanisms are applied to improve simulation efficiency on server-side and offer a real or accelerated-time simulation.

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Students' thinking processes when learning with computer-assisted mass lectures.

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This paper presents findings from a research project that examined students' thinking during mass lectures that utilized interactive multimedia (IMM). The data were obtained from six second year Thai medical students via stimulated-recall interviews. The reported thinking (or mediating) processes engaged in by the students during the mass lectures that related to the academic content of the physiology subject are detailed and discussed. We identified 18 different types of thinking skills including generating, anticipating/predicting, linking, metacognition, analyzing, and categorizing. These ranged from a high usage frequency (generating) to a low usage frequency (categorizing). Being able to understand such student thinking may result in more effective use of IMM in mass lectures. The data are also compared with studies that provided students' reported thinking processes when studying with the WWW, IMM, and text-based material. The significant differences in the mediating processes between using IMM in computer-assisted mass lectures, where the students did not directly interact with the IMM, and hands-on use of IMM, the WWW, and text-based material are discussed.

Keywords: **Thinking skills, Computer-assisted mass lecture, IMM, medical education, Thai medical students**

1 Introduction

There is increasing use of IMM in mass lectures in universities for teaching and learning. Yet IMM supported lectures do not guarantee better content learning or higher-order thinking than do traditional instruction methods. There is much research and literature concerning instructional design, the characteristics of IMM, and learning: for instance, the use of educational technology [1] and the effects of colors [2], animations [3], and interactivity [4]. Research has neglected how students engaged with the new technology in lectures. The research by Nowaczyk, Santos, and Patton [5] examined student perceptions of various characteristics of multimedia such as color transparencies, video, and PowerPoint in tutorials and mass lectures. However, they did not investigate students' thinking processes about the academic content. The research by Faraday and Sutcliffe [6] examined visual attention and comprehension of multimedia presentations. Research by Putt, Henderson, and Patching [7] and Henderson, Putt, Ainge, and Coombs [8] examined learners' mediating process about the academic content of IMM and WWW courseware, respectively. However, these did not focus on an IMM mass lecture context.

Studies report that IMM can be effective in encouraging higher order thinking skills when learners work with IMM individually or, better still, in pairs or small groups [9, 10, 11]. However, in a mass lecture, the IMM is controlled by the lecturer. Learners play a passive-receiver role. Are they focused on the content? What sort of thinking about the content do they engage in?

Heeding current literature in the field [1, 12, 13], the study does not aim to ascertain whether learningwith

IMM supported lectures produces better learning or test outcomes than traditional lectures. Rather, it utilizes qualitative methodologies to ascertain the students' thinking skills as they learned in the authentic context of a lecture theatre. Thus the study sought to:

(a) identify and categorize the thoughts concerning the content of the IMM supported lectures that were reported by the students;

(b) compare the mediating processes reported in the computer-assisted mass lecture study with those reported in research which identified the reported mediating processes that occurred in three studies where students had hands-on use of IMM software, WWW courseware, and text-based materials respectively; and

(c) with respect to (b), evaluate our hypothesis that the type of interaction with the learning materials would be a significant factor, that is, the lack of direct manipulation of the learning materials would result in lower percentage frequencies of reported mediating processes (our study) compared with those reported in the other studies that had direct hands-on interaction.

2 Methodology

Much existing research data regarding the efficacy of computer mediated environments is anchored in the process-product paradigm. The paradigm is based on the assumption that instructional stimuli give rise to learning outcomes. Recognition of the simplistic nature of this general cause-effect paradigm when applied in education, led to the adoption of the mediating process paradigm that focuses on student thought processes that mediate, or come between, instructional stimuli (the IMM supported lecture) and learning outcomes [14]. Mediating processes can be viewed as the fine-grained elements of cognition through which, and by which, learning outcomes are realized. Thus, learning outcomes are the function of the mediating processes activated by instructional tasks and other learning activities. Salomon [11] describes the contrast between analytic research that is focused on isolating effective instructional treatments and systemic research focused on understanding how instructional treatments work in practice. This study embraced systemic research focussing on the sorts of thinking that tertiary students engaged in during IMM supported lectures.

It is a qualitative study utilising stimulated recall interviews to ascertain students' thinking in authentic contexts. Learning is related to the quality and quantity of thinking undertaken by learners [15]. To categorize and tabulate students thinking skills, a process-tracing methodology is utilized. It involves appropriate self-reporting techniques through using a video to stimulate recall of cognitive processes engaged in during a learning/study session. The stimulated recall interview technique follows strict guidelines [14]. Triggered by such things as the students' non-verbal actions or what is appearing on the computer screen, non-leading questions are asked, such as: "You seemed to frown; can you tell me what you were thinking?" and, in order to confirm that the reported thought occurred during the learning session and not while being interviewed, "Did you think that then or just now?" Both the interviewer and students can stop the video when they believe something is significant and, for the student, when the video triggers a thought that he/she had had during the initial study session. This method has been used in different settings with different mediums and with individuals, pairs, and small groups [7, 8, 16, 17, 18].

2.1 Context, Participants and Data collection

The research context and methodology capitalize on authenticity [11]. The students' thinking processes were obtained in realistic, ecologically-valid situations as the data were collected from students working in their regular environment. Thus for the current study, the research was conducted with a physiology class in a mass lecture theatre, Faculty of Medicine Siriraj hospital, Mahidol University, Bangkok, Thailand. The lecturer used A.D.A.M., The interactive physiology-muscular system [19] in the one hour lectures. Two lecture sessions were video recorded. Six students volunteered to participate in the stimulated-recall interviews. There were four males and two females with ages ranging from 17 to 19 years. They were in the third semester of a six year Medical degree. The six participants self selected into 3 pairs, 2 male pairs and 1 female pair. Working in pairs was the favored study practice of these Thai medical students. The first male pair was interviewed after the first lecture session; the others after the second lecture session. The content of both lectures was the same topic and used the same IMM. All six participants attended both lectures.

The interviews were conducted with one pair at a time. The interviewer and each pair of participants together viewed a videotape of the lecture and a synchronized computer screen showing the A.D.A.M. IMM software that was used in the lecture. The video picture included the lecturer's verbal and non-verbal behaviors and the content of the computer-assisted lecture. The computer screen showed the A.D.A.M. IMM

software content which appeared on the videotape. Both videotape and computer screen facilitated the participant's recall and verbalization of their thinking during the lecture. The three stimulated recall interviews, one hour duration for each interview, were conducted immediately after the lecture sessions and were audio taped for later transcription and analysis.

3 Results

From the interview transcripts of the students' stimulated recall interviews, their thinking skills were identified, categorized, and then analyzed. Both authors together identified the thoughts from the first transcript. The others, they did individually. Then the data from each researcher were compared and discussed. Consensus was achieved when disagreement occurred. The data that were considered invalid, such as student's thinking that did not occur during the study session, the reports of students' activities that were not related to their thinking, and answers where the interviewer had led the student, were identified and discarded. Only students' thinking that occurred during the study session were identified as useable data.

The students' thinking data reported by participants were classified according to the mediating processes identified by Henderson, et al. [8]. The 18 mediating processes identified in our study are listed in Table 1 which provides a definition for each thinking skill and a clarifying example of each from the data.

Type	Description	Example
	Mental activity in which a student -	
Affect	reports feelings aroused by content during study	"He [the lecturer] clicked A. I was glad. My answer was correct."
Analyzing	Reduce, breaks down whole (e.g., problem, task) into parts	"I've learned that content. There were some new parts adding to it. The rest was old."
Anticipation	predicts or states expectations that problem, question, or textual feature will be encountered; wonders about: the possibility of an event, relevance of material, content	" He [the lecturer] was talking about timing. So, I thought ahead that it must higher. And when stimulated, a bit slower - it would be lower."
Applying	Considers the use of an idea, tactic in a different context.	"When I saw the clearer image, I thought they should use this technique in the textbook because it can't use animation."
Categorization	Sorts items, ideas, skills into different groups	"I thought I already noted this as asynchronous."
Comparison	identifies similarities, differences between two statements, concepts, models, situations, ideas, theories, points-of-view, etc.	"From the graph shown on screen, I thought it would appear in another way."
Confirmation	judges that ideas in text support one's own beliefs, practices, tactics	"When he [the lecturer] clicked, I just thought that one is correct."
Deduction	reasoning process by which a specific conclusion necessarily follows from a set of general premises	"I felt the image doesn't look real because the vesicle [4small bags within a larger bag] has just 4 bags and the water filled this space."
Deliberation	engages in "thinking" about a topic, prose segment, etc. (type of thinking not disclosed)	"I was thinking about the question."
Diagnosis	identifies strengths and weaknesses in idea, strategies, points-of-view	"I thought it made me understand better by cropping and enlarging the picture. So I can see it clearly"
Evaluation	makes judgments about the value, worthwhileness of textual materials, activities, in-text questions, own position or point-of-view	"I thought the topic shown at the top was good. It told me what I was going to learn."
Generating	formulates one's own questions, examples, ideas, or problems; interpolating; going beyond the data	"What does the handle look like? Stimulate by hands! Do we use hands to do that?"
Imaging	creates a mental image of an idea in text in order to gain a fuller understanding	"I thought about the real muscle and how it should look if I cut it"
Linking	associates or brings together two or more ideas, topics, experiences, tasks	"I thought about the frog's leg in the laboratory."
Metacognition	thinks about, reflects on, evaluates or directs own thinking	"I couldn't see the shrink in the first animation. I thought I need to focus more on the next one"
Recall	brings back into working memory an idea, opinion, fact stored in long-term memory	"This picture, I thought I learned it before."
Reflection	general indication of careful consideration or thought over past action and response; tries to establish the reason or causal link between the action and its response	"When this graph was shown, I thought the latent period is narrow. At first, I thought it would be wide and red like the previous one."

Strategy Planning	plans ways of processing or handling content material during study or learning sessions	"When I saw these, I would open the textbook. I did not wait. I would note the additional information in the textbook."

Table 1: Mediating Processes Identified in the Present Study

Note: Descriptions are adapted from Marland, et al. [14] and Henderson, et al. [8]; examples are from the current study.

The frequencies for each type of mediating process were tallied (Table 2). The data in Table 2 indicate the frequency of the 18 identified mediating processes. The data shows the different frequency of mediating processes between three pairs and the variation in the frequency of occurrence of mediating processes. These ranged from

Categories of classification	*Mediating Process (i.e., thinking skills)*	*Frequency (1st male pair)*	*Frequency (female pair)*	*Frequency (2nd male pair)*	*Total*	*Percentage (%)*
Content	Generating	3	19	11	33	14.5
	Anticipating/Predicting	1	10	20	31	13.7
	Linking	2	14	11	27	11.9
	Metacognition	11	7	6	24	10.6
	Evaluating	6	7	7	20	8.8
	Strategy Planning	0	6	10	16	7.0
	Recalling	8	3	4	15	6.6
	Affective	3	2	9	14	6.2
	Confirming	0	4	5	9	3.9
	Deliberating	1	2	6	9	3.9
	Diagnosing	6	1	2	9	3.9
	Imaging	0	0	7	7	3.0
	Reflecting	1	6	0	7	3.0
	Comparing	0	3	1	4	1.4
	Applying	1	1	0	2	0.9
	Deducing	1	0	1	2	0.9
	Analyzing	1	0	0	1	0.4
	Categorizing	0	0	1	1	0.4
	Total thoughts	45	85	97	227	100
	Mean number of mediating processes per pair from 3 pairs		76		based on responses	

Table 2: Frequency of Mediating Processes Related to Academic Content.

14.5% for "generation" to 0.4% for "analyzing" and "categorizing". A total of 227 mediating processes were identified from the transcripts. The mean number of reported mediating processes per pair was 76. The first male pair who were interviewed after the first lecture reported 45 mediating processes. The other male and the female pair who were interviewed after the second lecture reported 97 and 85 mediating processes, respectively. Familiarity with content and presentation probably influenced the higher number of thinking processes during the second lecture.

Mediating processes	*This study:* IMM in mass lectures (%)	*Study by Henderson, et al., (1997):* IMM study (%)	WWW study (%)	Text-base study (%)
Generating	very high (14.5)	high (8.4)	very high (10.1)	Low (3.6)
Anticipating/Predict.	very high (13.7)	high (7.8)	very low (1.4)	high (5.9)
Linking	very high (11.9)	very high (11.4)	very high (11.5)	very high (10.4)
Metacognition	very high (10.6)	very high (19.8)	high (9.4)	very high (12.4)
Evaluating	high (8.8)	very high (18.0)	very high (26.5)	very high (18.6)
Strategy Planning	high (7.0)	very low (1.8)	high (7.7)	very high (16.8)
Recalling	high (6.6)	high (6.6)	very low (1.0)	low (4.1)
Affective	high (6.2)	very high (14.4)	high (9.4)	high (7.8)
Confirming	low (3.9)	Very low (1.8)	low (4.5)	very low (2.8)
Deliberating	low (3.9)	very low (1.8)	very low (2.8)	none (0.0)

Diagnosing	low	(3.9)	none	(0.0)	low	(3.1)	low	(0.26)
Imaging	low	(3.0)	very low	(0.6)	very low	(2.4)	none	(0.0)
Reflecting	low	(3.0)	none	(0.0)	very low	(0.003)	none	(0.0)
Comparing	very low	(1.4)	low	(4.8)	very low	(2.1)	very low	(1.5)
Applying	very low	(0.9)	none	(0.0)	none	(0.0)	none	(0.0)
Deducing	very low	(0.9)	none	(0.0)	very low	(1.4)	none	(0.0)
Analyzing	very low	(0.4)	very low	(2.9)	none	(0.0)	very low	(1.1)
Categorizing	very low	(0.4)	none	(0.0)	very low	(1.0)	very low	(0.005)

Table 3:Comparative students' mediating processes frequency between this study and the study by Henderson, et al. [8]

The data in Table 3 show the variation in the frequency of occurrence of mediating processes in our study and that by Henderson, et al. [8] which reports data from three different studies. In these three studies, the tertiary education students had hands-on control of the IMM software, the WWW courseware, and the text-based materials. (Our research was not aimed at arguing that one type of learning material [the IMM in mass lectures, the hands-on IMM study, the WWW study, or the text-based study] was better educationally. Our intention with the comparison frequency of thinking processes was that, if the quality and quantity of reported thinking skills was comparable with those reported in the other three studies, and if hands-on interactivity did not appear to be a crucial factor, then lecturers would feel a level of confidence in using IMM in mass lecture.)

Based on four level divisions used in the Marland, et al. [14], Putt, et al. [7], and Henderson, et al. [8] studies, the frequency of occurrence is divided into very high, high, low, and very low in order. In all studies, the 3% and 10% cut-off figures were arbitrarily chosen, whereas 5.5% (100/18), the cut-off for the "high" category, was the average percentage frequency across all 18 categories.

In Table 3, the categories of generating, anticipating/predicting, linking, and metacognition have the highest frequency ($f>10$) in this study. According to the study by Henderson, et al. [8], linking was rated very high in learning with the WWW, IMM, and text-based materials as well. However, while anticipating/predicting rated as very high in this study, it rated as low in the WWW study and high in the IMM and text-based studies. Evaluating was reported often in all four studies. It was rated as high in this study and very high in the other three studies. Interestingly, strategy planning was very low ($f<3$) in the IMM study, but it rated as high in this study and the WWW study and very high in the text-based study. Recalling rated as high in only the two studies that used IMM. Comparison of the results show that ten mediating processes (confirming, deliberating, diagnosing, imaging, reflecting, comparing, applying, deducing, analyzing, and categorizing) occurred in the low to very low frequencies in all four studies.

4 Discussion

The following discussion focuses on the comparison of mediating processes that were reported by students during their learning sessions. In the computer-assisted mass lectures, the A.D.A.M. IMM software was used as a teaching-learning tool. It played a major role in the lectures. However, the students were not in a position that allowed interaction with the IMM. They were a group of passive-receivers who possibly consumed the content provided by the lecturer via the IMM features. Therefore, the data obtained in our study concerns the reported mediating processes of students who learned with IMM without direct hands-on interaction. The comparison data between our study and that reported by Henderson, et al. [8] reveals factors that influenced students' mediating processes while learning with different mediums. Moreover, it also revealed the differences in the quantity and quality of the reported thinking skills when students had direct hands-on interaction versus receiver interaction.

The top frequency percentages for the four studies are 26.5% (WWW), 19.8% (IMM), 18.6% (text-based), and 14.5% (our study). The data reveal a higher percentage frequency of the most reported thinking skills in the studies where students had hands-on interaction control. If we add the percentages of all mediating processes in the "very high" category for all four studies then the differences are 63.6% (IMM), 58.2% (text-based), 50.7% (our study), and 48.1% (WWW). Nevertheless, even though the students in the hands-on WWW study had the fewest reported mediating processes in the very high frequency range, there was only a small percentage difference (2.6%) between it and our study. In terms of these criteria, the data generally tends to support our hypothesis. The students in the hands-on IMM study obviously reported more mediating processes than those in the IMM computer-assisted mass lectures. However, when the number of mediating

processes per person in all four studies is averaged, the results are 38 per person for our study, 16 per person for the IMM study, 36 per person for the WWW study, and 28 per person for the text-based study. The low hands-on IMM number was affected by having learner groups of more than two students; beside two groups of two students there was one of three and one of four students in the stimulated recall interviews [20]. Nevertheless the highest number was in our study where students did not have hands-on control. Moreover students in our study reported more types (18) of mediating processes during learning. Students in the WWW, IMM, and text-based studies reported 16, 14, and 13 different types of mediating processes respectively. The students in the WWW study did not report applying and analyzing. The students in the IMM study did not report reflecting, applying, deducing, and categorizing. Those in the text-based study did not report deliberating, imaging, reflecting, applying, and deducing (Table 3). Breadth, that is, the number and type of different mediating processes are relevant to engaging meaningfully with the content as is the number per individual. Thus hands-on control does not seem to be the crucial factor here. The following discussion examines these issues concerning our hypothesis by singling out various mediating processes for analysis and reveals that our hypothesis is tenuous.

The top four mediating processes in our study were generating, anticipating/predicting, linking, and metacognition in descending order. "Generating" encompasses one or more of the following: (a) formulation of one's own questions, examples, ideas, opinions, problems, and answers; (b) interpolation by adding new knowledge through the elaboration of existing knowledge within a given framework; and/or (c) extrapolation which adds new knowledge by extending an existing framework and going beyond the data. The reason for the very high percentage for generating is because of the cause-effect relationship between their thoughts and the animation features of A.D.A.M., which led the students to focus on the content [21]. Generating has a very high frequency (14.5 %) in our study, a high frequency (8.4%) in the IMM study, a very high frequency (10.1%) in the WWW study, and a low frequency (3.6%) in the text based study. Therefore, direct hands-on interaction might have caused the lower frequencies of generating in the hands-on study. Students in the three studies reported by Henderson, et al. [8] might have engaged in the jobs they needed to do to control the IMM and the WWW materials and underline or take verbatim notes from the text materials. Thus resulting in less focus on the content. Students in the computer-assisted mass lectures just followed the lecturer's presentation, which may have allowed them to allocate more time to focus on the content.

"Anticipating/predicting" includes predicting, looking forward to, speculating about, and expecting the likelihood of encountering problems, types of content, and features of the medium. Anticipating/Predicting is the second highest ranked mediating process having a very high frequency in our study. It had a high frequency in the other IMM study. A possible explanation for this finding is that the lecturer was the only person who controlled the A.D.A.M. IMM software, thus the students anticipated and predicted what the lecturer decided to present and what would emerge in the A.D.A.M. presentation. Students in the IMM study had direct interactive hands-on control of the IMM. Therefore, it is possible that they automatically clicked the mouse to move to the next page, clicked for the answer to embedded questions, and clicked to control the animation without allowing time for anticipation or prediction. The very low score (1.4%) for the WWW study appears to be an anomaly. Perhaps the content, particularly the instructional design of the content, did not promote these thinking skills. Or perhaps the students used the hypermedia functions of the WWW and engaged in thoughts such as "I will click on this link" rather than wondered what content ideas would be presented embedded in that link. In our study, students in the computer-assisted lectures had to wait for lecturer interaction. Thus, during waiting, they had more time to anticipate or predict the coming content.

"Linking" had a very high frequency in all four studies. It is defined as the process of associating, or bringing together in the mind, two or more ideas, topics, contexts, personal experiences, words, and so forth. From this finding, linking occurred easily when text, picture, graphic, or animation that illustrated the concept prompted recall of an associated item in the student's memory. Therefore, it is not surprising that linking occurred very often in all studies because they contain those elements that influenced students to consider how the information related to their experiences. This also shows that, in comparison with our study, direct hands-on interaction did not influence the linking processes.

Mediating processes classified as "metacognition" are those in which students reported awareness of, reflecting on, evaluating, or directing their own thinking. This definition reflects a widely accepted view of metacognition as referring to students' knowledge about, and control over, their cognitive processes. The findings show that metacognition had the fourth highest frequency of mediating processes in this study. The students were able to engage with the content and thinking about their own thinking as it related to the content, and were less inclined to be sidetracked by the features of IMM, the lecturer, and

student-idiosyncratic factors [21]. Metacognition had very high and high frequencies in the four studies (see Table 3). In three studies the percentage frequencies were similar: our study (10.6%), the WWW study (9.4%), and the text-based study (12.4%). However, there was a significant gap between these and that for the hands-on IMM study (19.8%). A factor that possibly made the gap is that the hands-on IMM study contained embedded questions that forced students to interact in order to receive feedback and to be able to move to the next section. In our study, the A.D.A.M. software also offers the same feature, but the students did not have hands-on control. The text-based study also provided embedded questions, but did not provide feedback and also did not "force " the students to answer those questions. The WWW study did not provide embedded questions. This comparison shows that the different pedagogical instructional design in conjunction with the hands-on control is a crucial factor that influenced metacognition. Nevertheless, it is still significant that students engaged in metacognition, which is a type of thinking that is considered to be one of the highest types of cognitive processes [22].

"Evaluating" is defined as the mental process in which a judgement is made about the value or worth of some aspect of the content of the instructional material. Evaluating had a high frequency (8.8%) in this study. The percentage of reported evaluative thoughts about content is very high in the other three studies (18.0%, 26.5%, and 18.6%). The gap between our study and the other three studies is significant. The students in the other three studies used the learning tools by themselves. Thus, it would seem that hands-on experiences and, hence, control over their own pacing and navigated sequencing with the learning tools produced more evaluative thoughts. In computer-assisted lectures, the students may not have had enough time to evaluate the content as well as generate new ideas, link to their past experiences, or metacognise. Perhaps, the students in our study rationalized that if the lecturer had purposely selected out this particular IMM A.D.A.M. material then it was important. In the hands-on studies, the students had to make the evaluative decision as to what content was worthwhile or relevant to their individual goals.

"Strategy planning" refers to thought processes in which students plan ways of processing or handling instructional material or activities during study or learning sessions. There is a dramatic gap between the frequency percentage for IMM study (1.8%) and the other three: our study (7.0%), the WWW study (7.7%), the text-based study (16.8%). The students in our computer-assisted mass lecture study had to follow the lecturer's presentation. One could therefore assume that the frequency rate would be "very low"; but why then the very low score for the IMM study? There appear to be three explanatory factors. The first factor suggests, as is the case with lectures in general, in our study students planned how to deal with the information and process the content through note-taking, drawing graphs, and deciding whether to annotate the textbook or attempt to draw or describe the animations that they cannot control. The second factor is that the students in the IMM study when interacting with IMM, did not appear to spend time thinking about how they would process the material but instead just followed the linear sequence programmed as the "default" choice [8]. The third factor is that, in comparison with the IMM study, in which assessment was not a factor, the students in the computer-assisted mass lectures, the text-based, and the WWW studies knew that the content was assessable. This might have influenced the students' strategy planning.

"Recalling" is defined as bringing back into working memory ideas, opinions, and facts previously stored in long-term memory. It has a high frequency (6.6%) in both studies that used IMM while it was rated very low (1.0%) in the WWW and low (4.1%) in the text-based studies. The gap between the studies that used IMM and those that did not use IMM is substantial. It is possible that the features of the IMM products, such as animation and enforced embedded questions, encouraged students to recall their previous knowledge and experiences during learning.

It is interesting that confirming, deliberating, diagnosing, imaging, reflecting, comparing, applying, deducing, analyzing, and categorizing were rated as low or very low (see Table 3) in all four studies. The type of interaction (hands-on or receiver), the mediums and their features did not seem to influence these types of mediating processes. This implies that factors that should be considered are the content and whether its instructional design prompted these types of thinking skills.

5 Conclusion

It has been argued that IMM is more useful as a learning tool when used individually or with others rather than in mass lectures where students could be seen as merely passive receivers. Our study shows that hands-on interaction does not appear to be such a crucial variable. Indeed in our study, the quantity, quality and range in type of mediating processes were greater than, or comparable to, the other studies. Therefore, the authors argue that IMM can be used as a cognitive tool in mass lectures to enhance various thinking

shills. This study draws the attention of instructional designers and lecturers to the existence, types, and relative frequencies of mediating processes in which students engage with while learning with computer-assisted mass lectures. They were not passive receivers but active receivers. Our study highlights the need for instructional designers to plan educational materials that will activate desired mediating processes as part of student learning in computer-assisted mass lectures.

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The Automated Teaching Assistant: Automatic construction of teaching materials from course outlines

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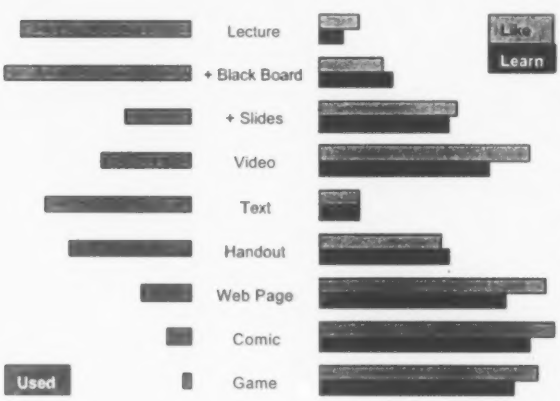
Keywords: **Lecture Preparation, Automation, Design of Teaching Materials.**

1 Educational Media: Yet Another Digital Divide

Instructors can use many media. Traditional teachers lecture while outlining on a black board; they assign readings from texts and printed handouts. Technological teachers lecture (or direct activities) while showing PowerPoint slides; they assign readings of web pages.

Instructors can use many media. Which do they in fact use? Which do students prefer?

We polled 200 students at three Japanese colleges. We asked students how often they saw, how well they liked, and how well they learnt from nine educational media. Responses were similar for all students across different colleges, different grades, and different majors. This graph summarizes their unified opinion.



The left side shows how frequently students saw each media. Common were traditional media (lecture, black board, text, and handout). Modern media were rare.

The upper bars on the right show how well students liked each media. The modern, rarely used were well liked. The lower bars show how well students thought they learnt from each media. Students claimed that well-liked media also taught the best.

In interviews, teachers claim they have no time to prepare multimedia slides and web pages, no time to learn PowerPoint. Students want multimedia; teachers don't prepare it. A digital divide separates a generation of computers from a generation of chalk.

How can we span this divide? These teachers brightened at the idea of a teaching assistant who would prepare these multimedia teaching materials, but only if the assistant could work from existing materials – typically typed course outlines – without supervision. They wanted a completely automatic teaching assistant.

So we created one.

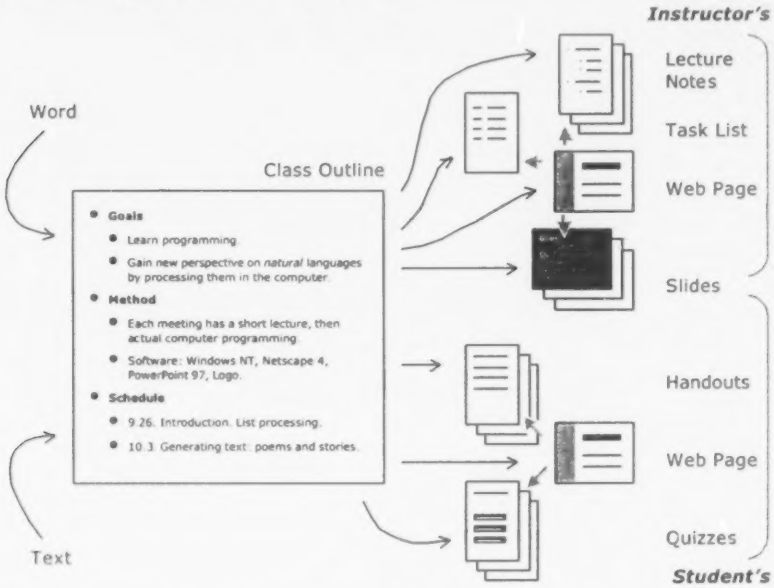
2 The Automated Teaching Assistant

The Automated Teaching Assistant (ATA) converts course outlines to multimedia teaching materials.

To use the ATA, instructors first prepare course outlines. They can use their favorite text editor or word processor, on any type of computer. Instructors then drag their saved file over the ATA program icon. The ATA reads the course outline and constructs a folder filled with teaching materials:

- syllabus (in the form of a class web page) [5]
- instructor's notes (teaching plans)
- student's handouts (outlines of each meeting)
- instructor's task list (things to do, to prepare this class, sorted by date due)
- graphical slides visualizing each point in the outline [3, 4]
- web-based quizzes, tests, assignments, polls, class evaluations, and peer evaluations [1, 2]

The sketch below shows how a class outline is translated to teaching materials. Black arrows show the flow of information; **gray** arrows show hypertext links:



All these materials are automatically uploaded to the class's web server. Then students can view the materials from anywhere in the world. Instructors can travel to any classroom in the world with a working web browser, and give their lectures. There are no papers or floppy discs to carry, no worries about hardware and software compatibility, no need to install software, no fear that needed software will be missing.

The ATA is completely automatic: it has no commands or options. Teachers submit their outlines; seconds later the materials are all available on the internet. This automation contrasts sharply with the common manual production of multimedia materials.

If instructors were to create these teaching materials without the ATA, they would need to purchase and then study expensive and complex multimedia software, such as PowerPoint and DreamWeaver. In addition, they would have to learn at least some design theory, for they would need to learn how to make attractive and comprehensible slides, handouts, and web pages. (Although some instructors might find this an interesting diversion, others may resent it as time stolen from their research and content preparation.) Then, before every class, instructors must manually convert their lecture plans into slides and web pages. In our experience, this takes an average of four tedious hours to prepare each meeting. Most instructors, in fact, are unwilling or unable to spend this much time preparing lectures. So students are disappointed.

But if these instructors would use the ATA, it will cost them only seconds, but will greatly increase their student's satisfaction. The ATA is more efficient because it factors the *style* (layout and design) out of the

substance (logic and content) of teaching materials. Instructors need concern themselves only with the creation of the abstract content of their classes; They can delegate the tedious physical layout and distribution to the ATA.

Using the ATA, we prepare lectures in an average of 40 minutes. The ATA allows us to prepare in only 17% of the time – it speeds preparation five times.

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The Criteria and Evaluation of Metadata/Keywords in Image Retrieval

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Nowadays, a large amount of digital images are being stored worldwide in Internet. As an educational means, images stored in Internet have a big potential. Teachers can show the students pictures or images instead of actual things. The Internet is so rapidly expanding and becomes so complicated that the ways to retrieve images effectively from Internet database are now getting more difficult. In this paper we consider an image database about metadata type. We place a special emphasis on keyword itself in the metadata, and show the criteria of keyword, not the framework of them. Good keywords are needed in the database so that the retriever can get what he/she really wants. First we survey the necessity of metadata: especially keyword for image database. Next we consider and present the criteria for consistent and appropriate keywords, distinguishing subjective keywords from objective ones. And we examine and assess them. Furthermore we append a new item, importance, to our criteria.

Keywords: **Image Retrieval, Metadata, Criteria**

1 Introduction

Over the years large amounts of computer-aided images are being stored in Internet owing to widely available digital recording devices, such as digital cameras, scanners, and economical large size storage. For the effective management of those digital images, an image album or an image filing system has the subject of study and it has remarkably developed. And the Internet is so rapidly expanding and becomes so complicated that the effective retrieval methods of images from database becomes more and more important.

As an educational means, image presentation is very important. Because teachers cannot usually bring actual thing into classrooms, they show students the pictures or images instead. Or when the students use the Internet by themselves the images surely help them to learn fast and effectively.

There are 3 kinds of image database: feature type, sensitiveness type, and metadata type. Feature type (cited as [1] and [2]) is based on the colors or shapes of object in the images. When the retriever puts in color or shape, the system starts searching directly the database with color histograms or shape. In the case of sensitiveness type (cited as [3] and [4]), the retriever puts in sensitive words and the system exchanges them for color information and searches the database. In the case of metadata type (cited as [5]), each image in the database is already given metadata, which explains its characteristics by texts or digits, and the retriever searches the database using the metadata.

Our concern in this paper is of metadata type. Of this type, first, database creators define the structure or the framework of metadata. Second, database administrators attach metadata to images according to it in the database. Third, a retriever specifies texts as a key to the database. Finally the database system searches images using the metadata which is given by administrator and also using the texts which are keyed in by the retriever. Examples of metadata are keywords, texts, classification items and so on.

The metadata of image database system metadata needs consistency and appropriateness. If it often happens

that some of metadata are irregular or incomplete, the retriever cannot find images which he/she really wants. Especially of commercial systems, the reputation of the database is determined by the quality of metadata.

We place special emphasis on keywords in the metadata because they are the basic component of metadata. In Section 2 the necessity of metadata, especially keyword of image database, is discussed. In Section 3 the criteria of consistent and appropriate keywords is considered. In Section 4 the criterion, which we discussed in Section 3, is examined. In Section 5 our conclusion is presented and the future work is discussed.

By the way, we are not concerned here the structure or the framework of metadata. It needs another consideration. In ISO, the structure of metadata for multimedia contents description, MPEG-7 [6], is now being standardized. MPEG-7 will provide the distribution and utilization of multimedia contents with content-based retrieval. The application will be distance learning, a stream database, a personal TV, and so on. MPEG-7 will become International Standard at September 2001.

2 Metadata and Keyword

Good metadata is needed in the database so that the retriever can get what he/she really wants. In storing database with images, we give texts, especially words as metadata to them. These words can be defined as keywords. They are given to images and used when a retriever searches the database. Database system searches images based on keywords which he/she specifies.

Therefore when incompatible keywords are given to images in the database, a retriever cannot get images which he/she really wants, even if he/she puts in any compatible keywords. In next Section we show the criteria of good keyword, which discussed and experienced before in [7].

3 The criteria of keyword

We shall discuss the criteria of keyword in detail.

- Giving appropriate keywords

  A retriever depends only on keywords. Therefore the images need to be given beforehand the keywords which represent them precisely. For example, we should distinguish "people" from "doll" because he/she may really want the image of a doll, not of people. Or it depends on the retrievers of the database which is appropriate "car" or "BMW". The database administrator should expect how the retriever uses keywords when he/she gives keywords to the image.

- As many keywords as possible

  An image has a lot of views. For an example, in Figure• ; some people takes it for the figure of pond, some of others for monument. Obviously only a single keyword is not adequate to describe its whole concept.

  Therefore, a number of keywords should be given to an image so that it can precisely correspond to the keywords. The retriever can more easily obtain the images which he/she really wants.

- Distinguish subjective keywords from objective

  We can define a lot of keywords for one image. They may be divided into two types. One is objective; the other is subjective. In figure• ; objective keywords are, for example, "pond", and "monument". Whereas "summer" and "shine" are subjective factors, because they are viewer's impressions of this image. They are subjective keywords. The former is more general than the latter.

You might think that you need only objective keywords. However, a retriever's needs are generally divided into two types: subjective and objective. In Figure• ; he/she wants a summer picture. "Summer" is a subjective word. If the database does not have subjective keyword, he/she cannot find such an image. He/she must hit objective keywords instead of "summer". Accordingly there are subjective needs in so many cases that subjective keywords are to be needed. For this reason, both subjective and objective keywords are needed in an image database.

And subjective keywords are to be distinguished from objective ones. Here is an example. A retriever wants

an image of "sea atmo sphere". In a database, one image represents the impression of sea, that is, "beach". The other image represents the sea itself. When he/she specifies a keyword "sea", the database system searches an image with keyword "sea". It hits two images: the sea itself and the beach. However, what he/she really wants is the sea image, not a beach one. So that a subjective keyword should be given a subjective marker in the database, to distinguish it from objective one. The retriever finds the image more easily and precisely by putting in the keywords with a subjective marker. Such is the criteria of keyword.

4 Examination and Assessment of the criteria

We examined above mentioned criteria to assess the effectiveness.

We arranged seven persons (5 males and 2 females; all adults). First of all, we showed them our criteria discussed in Section 3 as a book-style. We call it "keyword book". Next, we show them 20 images, one per one paper. The contents of them are sight, animals, texture and so on. We included pictures of various image types. We scanned, digitized and printed pictures by a color laser printer. Then we let them give keywords to these images. They gave keywords to the images referring the keyword book as many as they liked. We did not limit the number of keywords for each image.

Finally we let 3 specialists give keywords to same images separately. And we compared the former keywords (by 7 persons) with the latter keywords (by 3 specialists) so that we might assess the contents of both keywords. In the following section we discuss about the result of this examination.

4.1 Number of keywords and the appropriateness

The result of our experiment are presented in Table• ; Total number of keywords is 416 for 20 images. In average there are about 21 keywords for an image. The relationship of keywords and object in each image is roughly as many. The specialists added total 103 keywords to those given 7 persons.

It is the tendency that specialists give keywords to the small objects in each image. Especially there are a lot of objective keywords, which are given to images that has many objects. 7 persons and 3 specialists gave the same keywords to Figure• ; But to Figure • ;7 persons gave only 5 keywords: while 3 specialists did 29. And the keywords by 7 persons are different from the ones by 3 specialists.

The keyword is for retrieval. We need not say that keywords should be given to as many as possible to improve the preciseness simply because the objects in the image are very small. Generally the more keywords the image is given, the easilier it can be searched out. But, on the contrary, from the point of appropriateness, we claim that the images should be added the information regarding the objects in it; for example, how large it is, or what impression a person has when he/she looks at it. This is to help the retriever to obtain the image which he/she really wants. The database should have such information. However, there is no information about them in our criteria.

It follows that an index is needed to show the importance of keywords or square measure of objects in the image: for example, the keyword "monument" and importance "3", or monument has one-fifth (of the image).

To the images that cannot be dis tinguished by the object such as texture and patterns, the keywords of 7 persons vary widely compared with ones by specialists. For example, in Figure • ;7 persons gave "red", "water-drop" and "discomfort". The object in it is so hard to define that they are difficult to give keywords to this texture and pattern. In educational situation, this is a serious matter because students are not generally able to hit such keywords to retrieve them. In short, we point out that metadata type is of limited use when images are given in pattern or texture style. So that it seems reasonable to say that feature type retrieve is better for them than metadata type.

4.2 subjective/objective keywords

In Table• ; subjective keywords are 81, 21 % of total keywords. And the specialists gave 7 subjective keywords, which is 10 % of 7 persons' keywords. On the other hand, the specialists gave 96 objective keywords.

Regarding subjective keywords, there is little difference between 3 specialists' and 7 persons'. On the contrary, regarding objective keywords, 3 specialists' are different from 7 persons'. In addition to this, 7 persons' keywords are lacking of uniformity. There are only a small number of common subjective keyword that both 3 specialists and 7 persons.

Therefore it follows that there are limited words that express the character of images subjectively. The number of subjective keywords using these limited words is so small. On the other hand, regarding the objective keywords, 7 persons mostly attached them to even the objects which occupy the main part of the image, while 3 specialists gave them to even the small objects. We may say that that caused the increase of their keywords.

	Total	Subjective	Objective
Seven Persons	313	74	239
Three Specialists	103	7	96
Total	416	81	335

Table• •Number of Keywords

4.3 Discussion about our criteria

As mentioned above, we must modify our criteria because they will be to include the importance of each keyword.

• Appropriateness• The database administrator should expect how the retriever uses keywords when he/she attaches keywords to the image. As mentioned above, he/she distinguishes or identify "car" with "BMW". If the database is for general use, both general noun "car" and proper noun "BMW" are also given.

• Number of keywords• It needs the number of object that the image has and at least one subjective keyword which express the characteristics of image.

• Importance• It newly is appended our criteria. Importance: 3 is that the object is very large in the image or that it express the characteristics or the main theme of the image. Importance 1 is that the object is as small in the image as people try to find. The other object or character in the image is importance 2. For example, in Figure • ;keyword: keyboard, importance: 1; keyword: PC importance: 2 and in Figure• ;keyword: cat, importance:3.

• Subjectiveness/objectiveness• objective keywords should be given for all object in the image and subjective ones are given to at least one word for the impression by the image. Each keyword is appended subjective/objective marker or one s coded to numerically.

5 Conclusion

In this paper, we considered and the criteria of metadata, especially keywords for image database and image retrieval. We emphasized importance of consistency and appropriateness. We examined the criteria by experimenting 10 testers and verified them. And we added a new measures, "Importance" to our criteria

When a lot of persons give keywords to images, such criteria are indispensable. In our future study, we will concerned and define the structure or the framework of metadata. Furthermore, We will integrate metadata type and feature type for pattern or texture.

In the future, we hope that multimedia retrieval with metadata will be much easier for all people. So the teachers will be able to utilize more accurate images in education, and the students will be able to easily retrieve images from Internet.

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Figure• • an example of image

Figure • • image with one object

Figure• • image with many objects

Figure• • Texture

The Development and Evaluation of a Learning Support System for Converting Web Pages

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In recent years, the use of the Internet for school projects has become popular, even in the primary level. One of the difficulties in the use of the Internet is the arrangement and integration of Web materials to meet the learner's goals. This paper presents a tool that will help meet this challenge. It will also describe how the tool was developed and what are the results of its evaluation. The features of this tool are the following: 1) learner can easily gather Web pages as thumbnail of a screen image; 2) learner can make a list of thumbnails; 3) thumbnails can be sorted, with comments added; 4) arranged thumbnails can be displayed by HTML. Further, the learner can make a presentation using thumbnails. The authors later conducted an experiment to verify the effectiveness of this tool in arranging Web pages. The developed thumbnail tool and the browser's bookmark tool were compared. The results showed that our developed tool was more effective than the bookmark tool, especially in following areas: (1) more recognizable contents of Web pages (2) easier operation, and (3) more user-friendly for students.

Keyword: **WWW, Exploring Projects, Screen Image, Thumbnail, Bookmark**

1 Introduction

In recent years, the use of the Internet for school projects has become popular, even in the primary level. In Japan, Ministry of Education will implement the integration of technology in K-12 starting 2002. Thus, students will need to have the skills needed when using the Internet for various school subjects. For project-based learning using the Internet, the popular tool for surfing and gathering online data will be the search engine. It enables the easy gathering of various online data. But not all online data is reliable and accurate. Also, if not updated, the data or information in web pages can become obsolete. So learners need a tool that will help collect, select, organize and integrate the web pages that meet their learning needs.

Currently, the tool that is available to learners is the bookmark tool. It enables users to save Web pages with its title. It also makes it easy to access the web site's URL. But the bookmark tool leaves much to be desired in terms of the organization and integration of online data. Because data gathering using search engines is a vast task, there is an immediate need for easy browsing. The bookmark tool is a tree-structured file system, which is not quite adequate for quick and easy browsing. Moreover, it is hard for learners to appreciate the significance of Web pages when they appear only as text names when bookmarked.

In addition to doing research projects, learners also engage in making presentations of their projects using the Internet. To help learners in this activity, the authors proposed a tool that will provide students an easy way of making a file for their presentation. So, the authors developed and evaluated a learning support system which will enable learners to arrange and integrate Web more effectively.

2 Conceptual Framework for Tool Development

To reduce the load on making our choice information , the following 2-part approach was taken:

(1) The centralized of system approach. In advance searches, the tool will automatically narrow down the search to the closest level possible (filtering approach). This means the goal is an intelligent tool that can select information and improve the precision of narrowing down the search.

(2) The centralized of human approach. By adding available information as hint, in order to reduce extraneous information. This a support to the select available information.

The overall goal of this 2-part approach is to enable an easy narrowing down of a search.

When gathering web pages for a school project using the Internet, the tool that was developed by the authors enables the capturing of web pages and viewing them as thumbnail images. The authors believe that thumbnail images are more effective in providing visual cues of the content of Web pages. And, by displaying thumbnails, learners can arrange Web pages holistically, that is, they can visualize the whole composition. The authors made the hypothesis that more visual information as that provided by thumbnail images will be more effective when arranging Web pages for a project or presentation.

For presentations, the popular tool is Microsoft PowerPoint. Compared to OHP presentations, the use of motion pictures and animation makes a presentation more dynamic. But for children who are beginning computer users, the use of such tools may not be easy or may require more technology resources than what is available. But, by converting web pages directly to a HTML coding for presentation, the learning curve will be lower. So the authors proposed to add the function of being able to integrate selected web pages into a HTML coding for presentation in the development of their new tool.

3 The development of the new tool

3.1 Overview of the new tool

The developed new tool enables users to arrange Web pages using thumbnail images (**Figure1**). The functions of the developed tool are: listing thumbnails, sorting, and scrolling. The added function of a memo or comment line is to enable the users to add new information or data. The developed tool will then automatically generate the HTML coding for presentations. Through the use of HTML, learner can easily make a presentation (**Figure4**). **Figure2** shows the system configuration. The procedure for the use of the developed tool is as follows:

1) Learner displays Web pages or self-produced HTML pages using Web browser.
2) Screen image of Web pages and page title are saved to a database.
3) Lists of thumbnail from the database are displayed. Learner arranges web pages on the display, and add own comments to thumbnail.
4) Finally, using the arranged materials, learner makes a simple presentation

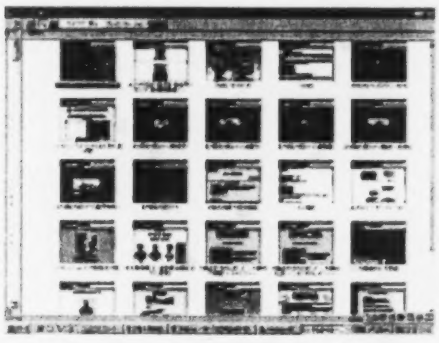


Figure1: A page showing the list of thumbnail images 1

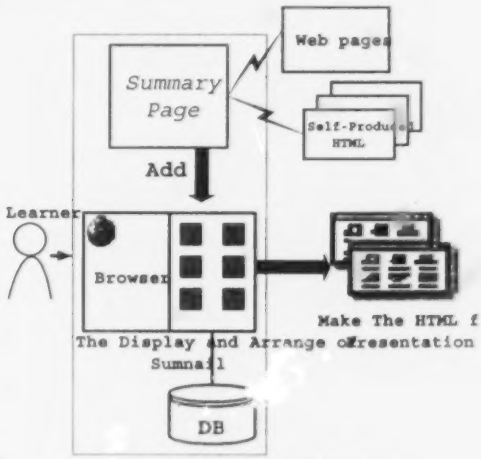


Figure2: System Configuration

3.2 The type of display Web page

In displaying the collected Web pages, the following 3 modes were used,
[1] Converting to thumbnail screen images
[2] Manipulating the original Web pages
[3] Making a presentation
The following sections explain further these 3 types.

3.2.1 Converting to thumbnail screen images

When selecting Web pages to put together, the user clicks a button to add a Web page. The web page is then converted to a thumbnail screen image (**Figure3**). Thumbnail screen images are Bitmap file made of large volume of data, so this Bitmap file is converted to a JPEG file. After that, the thumbnail is saved to the database.

3.2.2 Manipulating the original Web pages

By double clicking the thumbnail screen image, the learner can access the original Web page. It is just conceivable that learner will want to arrange the thumbnail web pages, and at the same time, have access to the original web pages. **Figure3** shows how the original web page and the lists of thumbnails are displayed at once. To change the display size, the learners can move from side to side, the display size control button located at the center of the display.

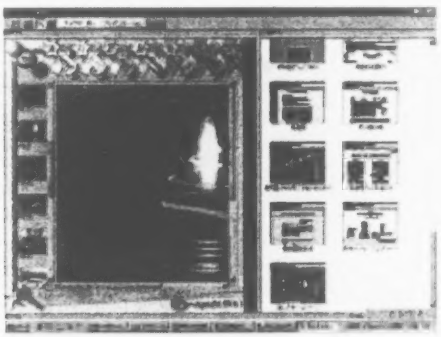


Figure3: A page showing the list of thumbnail 2

3.2.3 Making a presentation

Figure4 is the display of HTML for presentation. Arranged thumbnails are displayed in a sorted order. Learners can make a presentation using the display. Each Web page is composed of a link to the thumbnail, a link to the URL, and an area for comments or memo. The purpose here is to provide a function that will enable the easy arranging and integrating of Web pages for a presentation.

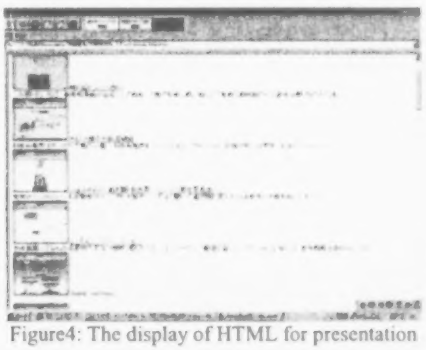


Figure4: The display of HTML for presentation

4 Evaluation of the tool

4.1 Purpose

The object of this evaluation is to verify the usability of the tool developed by the authors. Particularly, it will study the thumbnail screen images' usability for arranging Web pages. The subjects are the tool group using the developed tool and the bookmark group using only the regular bookmark tool. The groups were given the task to arrange Web pages about a specific theme. To collect data, the following were done:

(1) conduct a questionnaire survey. Subjects evaluated the operationality of the tool and were asked to give written comments of their experience of using the tool.

(2) In terms of arranging web pages, users compared the tool with the bookmark tool, and the analyses of the following data items were done.
   1. work time
   2. total number of times a URL is accessed
   3. number of times a URL is re-accessed (the same Web page is accessed more than 2 times)
   4. number of times thumbnails are sorted
   5. number of times thumbnails are deleted

4.2 Method

The subjects arranged Web pages based on a theme using the developed tool and the bookmark tool. Thirty (30) Web pages were prepared in advance by the experimenter. To get a history of how they operated the tools (history of operation), a video record of how the subjects used the tool was made from a TV converter to a VHS video tape. After the experiment, the subjects answered the questionnaire. The experiment had the following stages

1. The use of the developed tool and the bookmark tool was explained to the subjects;.
2. The content of the task (theme of project) was explained to the subjects
   Theme A: the sights of Tokyo that you want to introduce to friends
   Theme B: the sights of Osaka that you want to introduce to friends
3. To eliminate order of effect, the subjects were divided into 4 groups (Table 1).

	Former	Latter
1Group	Theme A Using the tool	Theme B Using bookmark
2Group	Theme B Using the tool	Theme A Using bookmark
3Group	Theme A Using bookmark	Theme B Using the tool
4Group	Theme B Using bookmark	Theme A Using the tool

Table1: Subject groupings in the experiment

4.3 Results

To compared the developed tool and bookmark tool, questionnaire data was analyzed for significance using the t-test The results are given in **Table2**.

	Average	Result
Thumbnail screen image is more recognizable	4.17	**
The lists of thumbnail are more recognizable	4.17	**
Useful for arranging web pages	3.83	*
Recognizes the contents of a web page	4.33	**
Useful for school projects that use the Internet	4.67	**
Useful for making a presentation	4.42	**

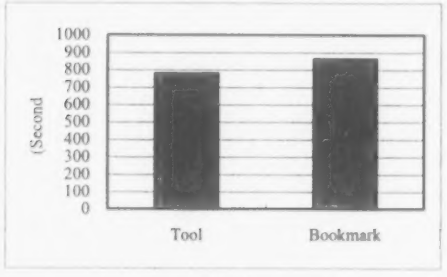
*p<.05,**p<.01 t-test (two-tail test) the average(max5)

Table2: The results of the questionnaire

T-test results show that web page titles with thumbnails are more recognizable than text-only web page title. And as to browsability, the lists of thumbnail are more recognizable than the tree structure of the bookmark tool. Inquiry as to "useful for arrangement" was significant at the 0.05 level. But as to the ability of operation in the questionnaire, couldn't get level of significance. Because the interface of sorting the thumbnails will not be enough to good for learner.

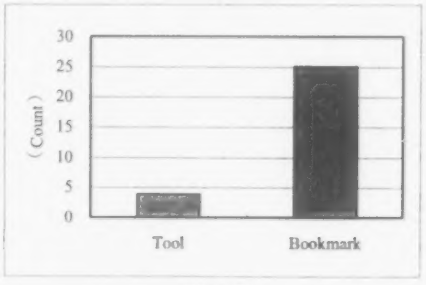
In the analyses of the history of operation (reference 4.4 (2)), the record shows that the thumbnail screen image is useful to learner when arranging web pages. The results are indicated in **Figure6-10**. From the results, the following items were verified:

* For shorter work time, the developed tool is comparatively more efficient than the bookmark tool (Figure6).
* By using the thumbnail screen image, the learner is able to better recognize the contents of the web page (Figure7,8).
* Lerner is comparatively able to estimate whether to use web pages or not (Figure10).



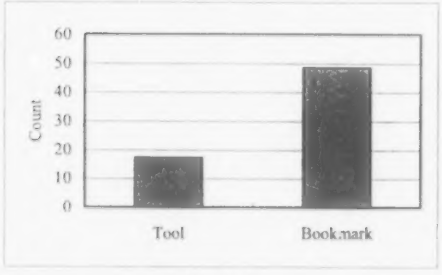
+p<.1

Figure6: Comparing the average of work time



**p<.01

Figure8: Comparing the average number of times of re-accessing URL



**p<.01

Figure7: Comparing the average of the total number of times of accessing URL

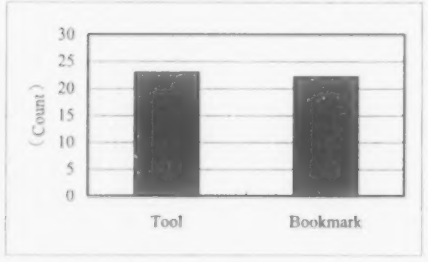
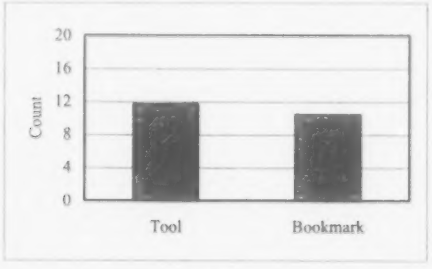


Figure9: Comparing the average number of times of sorting thumbnails



+p<.1

Figure10: Comparing the average number of times of deleting thumbnails

4.4 Analysis

The results of the evaluation procedures show that

1) based on the questionnaire, there were good results as to the functionality of the thumbnail screen images. And from the subjects' comments, "the lists of thumbnail is useful", "helps better recognize contents of the web page", and "the arrangement of web pages using the tool is convenient and useful".
2) based on the results of history of operation, work time, in terms of the number of times of accessing and re-accessing the URL and the number of times of deleting thumbnails, got good results in the given level of significance.

In terms of browsability, providing the user with a list of thumbnail is more useful than the bookmark tool. Accordingly, for arranging web pages, the list of thumbnail was better for integrating the collected data and for reviewing them. For arranging web pages, the results of the history of operation show that the developed tool is more useful than the bookmark tool.

5 Conclusions

In this research, a tool for learning to support the arrangement and integration of web pages was developed and evaluated. The results of the study can be summarized as follows:

1. Development of the learning supporting tool
   This research addressed the problem of selecting information for research projects using the Internet [1.Introduction], and examined how to resolve the problem by developing a tool that is both effective and user-friendly. The research also considered the interface of the tool and provided a conceptual framework [2.Conceptual Framework for Tool Development] in its development.
2. The evaluation of subjects about ease of operation and usefulness of the tool
   In the experiment phase of the paper [4.The evaluation of tool], a questionnaire was used to measure the as to ease of operation and usefulness of the tool., and got good results.
3. Verifying the efficiency of the tool for manipulating web pages
   When it comes to accessing and re-accessing URLs, the tool was more useful than the bookmark tool. For arranging web pages, the availability of a list of thumbnail images made it easier to integrate the selected web pages and to review them.

5.1 Future Studies

For future studies, the following are recommended:

1) Modification of the tool and adding more functions
2) A detailed analysis of the operation history

Acknowledgement

The authors would like to thank Dr. R. Santiago for her great assistance.

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The Estimation of Music Genres Using Neural Network and Its Educational Use

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To develop a learning support system of music genre, a neural-network-based system was developed that can estimate the genre of music from partial information of a standard MIDI file of music. Standard MIDI files of 120 music titles has been identified into 4 genres, Japanese Popular Ballad, Jazz, Hard Rock and Heavy Metal after the Neural network of the system had been trained. Comparison shows that, the system developed, has a higher judgment rate than that of subjects. Next, the weight of the links were examined by an expert, 5 of the nodes in the Hidden Layer could be extracted.

Keywords: **Music Education, Neural Network, Intellectual Learning Support, MIDI**

1 Backgrounds and Objectives

Recently, popular music, for example *Beatles* etc, is included in recent music textbooks of Elementary, Junior High and High Schools in Japan. So, it is thought that music education using popular music will increase more and more in course of time. When students learn popular music, music genre of the music is an important factor[1]. In order to learn the musical feature of each genre, it is thought to be very effective. Systematic genres studying of popular music, in which students seems to be interested, is thought to be a way of the students' music experience enrichment.

An "Automatic Composition MAGIC (Music system for Arrangement and Intelligent Composition) Considering Music Style" was developed [2] by Minamikata in 1989 is one of the researches in the research field that treats plural genres of popular music. This System supports composition and adaptation using heuristic rules divided by music taste of genre. It is said that rule-based system like this is effective when the system reproduces a already-known music taste or rule for the system, but there is an anxiety that generated music is conventional, and it is a problem for an unknown taste.

It can be said that the genre of popular music is the combination of different music. Now, many researches have done the grouping of music. Concerning Neural Network-based research, the research of Sakamoto (1999) grouped the music according to the sensibility information by using SD method [3]. If consider the flexibility and generality grouping by neural network differs from that of grouping by rules or multiple different analysis. So, it is said that moderate result can be expected for any unknown input by the process of grouping by Neural Network.

Based on the above research, we aim to develop the learning support system which can provide feedback on "Feature as the genre" of an unknown music with the Neural Network training of the music of various genres. Based on the above-mentioned background, we conducted this research in the following way. At the beginning, reserve experiment was done by an expert of popular music to confirm the factor for the estimation of the genre. Based on the obtained finding, we trained the Neural Network. Here the Neural Network was composed using the partial information as input signal and genre of the music as output or

teaching signal. In order to use this system for education purpose in the future, the meaning interpretation for each factor of the Hidden Layer of the trained Neural Network was identified by an expert of popular music. Then, the genre estimation experiment was done using the subjects who seemed to have general experience of popular music. Lastly, the estimated average result of the subjects and the estimated result of this system was compared to show the effectiveness of this system.

2 Estimation of Music Genres by Expert

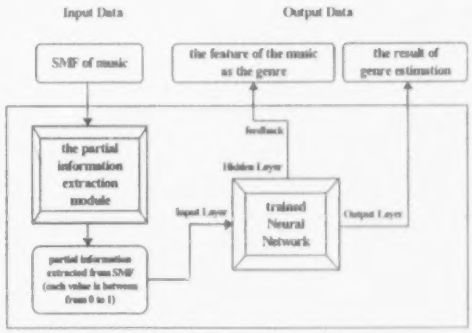
When music and genre are trained to the Neural Network, the problem is that we should take data to make an input signal from a long standard MIDI file. Therefore, we examine the mounting method of this system by knowing how the person judges the genre. For that, in the preliminary experiment we ask the expert about the factor of the genre estimation. The subjects had different musical instrument performance experience for ten years or more. The procedure was that they were made to listen ten in total of five genres. Also the factor to estimate the genre was interviewed. As a result, the following factors were found.

(1) The factor to estimate the genre is various according to the genre, and it's vague information.
(2) The factor to estimate the genre is local & partial information.

From (1), at first we got to the hypothesis that the estimation of music genre based on rules is very difficult and not proper. Under the above hypothesis, we propose to use Neural Network to deal with vague information in this research. As the input from (2), we judged that it was appropriate to extract partial information that seemed to be necessary for estimating the genre of music, and to assume it to be an input value of the Neural Network. The standard MIDI file (Hereafter, it is abbreviated as SMF) that is already a descriptive language was used as music.

3 Genre Estimation System

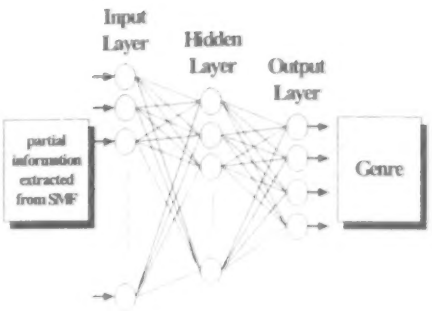
Figure.1 shows the composition of the genre estimation system. The flow of this system is as follows. When the user inputs SMF of music, the partial information extraction module extracts some partial information from the music. Then, it is put to the Input Layer of the Neural Network that has already been trained for music and the genre. The Neural Network feeds back the result of estimating the genre obtained from the Output Layer. Moreover, the feature of the music as the genre obtained from the Hidden Layer is planned to use as feedback in the future. If the module is developed, the user will be able to learn the genre.


Input Data
Output Data
SMF of music
the feature of the music as the genre
the result of genre estimation
feedback
the partial information extraction module
Hidden Layer
Input Layer
trained Neural Network
Output Layer
partial information extracted from SMF (each value is between from 0 to 1)

3.1 Extraction of Partial Information from SMF

SMF of the General Midi correspondence was used in this research. SMF includes various musical information such as Note-On (time of starting to ring each music sheet), Note-Off (time of finishing to ring each music sheet), Velocity (the strength of each attack), Note Number (pitch), and Program Number (kinds of musical instruments and tones) etc. The following three information of these score information were decided to use in the partial information extraction module.

1. Kind and tone of musical instruments extracted from Program Number (henceforth, we call it "Musical Instruments and Tones", which is expressed by an array of 128 Boolean type variable. Each valuable shows whether musical instruments (tones) of Program Number 1-128, were used in that music or not.).



Distribution of Rhythm extracted from the statistics of position of Note-On per a bar (henceforth, we call it "Distribution of Rhythm", which is expressed by an array of 16 integer type variable. Each variable shows the frequency for which Note-On event is held at the rhythm in one bar in the SMF.).

Distribution of Pitch extracted from the note number (henceforth, we call it "Distribution of Pitch", which is expressed by an array of 12 integer type variable. Each variable shows the frequency for which each pitch of 12 music scales is used in the entire music of SMF.).

3.2 Composition of Neural Network

Figure 2 shows the composition of the Neural Network. We adopted the Back-Propagation algorithm as the learning algorithm of the Neural Network. For the input signal, we used a combination of the values.

4 Outline of Genre Estimation Experiment using this system

4.1 Method

By the above-mentioned methods, the genre estimation experiment by this system was performed. 120 music titles of SMF which are composed of 30 titles each in Japanese popular ballad, Jazz, Hard Rock, and Heavy Metal, tried to be learned by the Neural Network. In this research, the combination of the following partial information was learned as an input data.

Musical instrument and tone 128bit
Distribution of rhythm 16bit
Distribution of pitch 12bit
Musical instrument and tone, Distribution of rhythm (+) 128+16=144bit
Distribution of rhythm, Distribution of pitch (+) 16+12=28bit
Musical instrument and tone, Distribution of pitch (+) 128+12=140bit
Musical instrument and tone, Distribution of rhythm, Distribution of pitch (+ +) 128+16+12=156bit

The number of units of Hidden Layer in each Neural Network is assumed to 10-30. The number of units of Output Layer is as many as the number of genres that the Neural Network learns. In this case, it requires four units in Output Layer, because there are four genres.

4.2 Result

The result of training is shown in Table 1. In the Table 1, "NN" means Neural Network, and - in NN means the Neural Network whose input information is described above. The result of training, NN was converged about 650 learning times, and

NN	Input Layer	Hidden Layer	Output Layer	Judgment Rate	Judgment Percentage	Learning Time
	128	20	4	119/120	99.2	X
	16	10	4	97/120	80.1	X
	12	10	4	103/120	85.8	X
	144	30	4	120/120	100	About 650
	28	30	4	111/120	92.5	X
	140	30	4	119/120	99.2	X
	156	30	4	120/120	100	About 1100

NN was about 1100 learning times, but other NN were not converged within ten thousand learning times. So, the trained Neural Network was able to judge the genre of learned music at 100%.

From this, it is suggested that the Neural Network like - that has single partial information in Input Layer can't finish learning, But the combination of those partial information make it enable to learn. This result supports the findings of experts at the preliminary experiment in Chapter 2 whose also says that the factor to estimate the genre is various according to the genre.

4.3 An Analysis of Hidden Layer

The Hidden Layer in the Neural Network is analyzed here. There is a heuristic method that each cell's tendency in which it is likely to make active or inactive is found by an expert, and then the meaning of factor is obtained[4],[5]. We used that method here.We focused on the weight of the link between Hidden Layer and Output that is above 10. Each unit from No.1 to 5 are activated by following genres.

Unit No.1: Hard Rock
Unit No.2: Hard Rock, Jazz
Unit No.3: Hard Rock, Jazz, Japanese Popular Ballad
Unit No.4: Heavy Metal
Unit No.5: Japanese Popular Ballad

Table 2. Analysis of Each Factor in Hidden Layer

Unit	Name of Factor
1	Hard Tone Factor
2	Synthesizer Tone Factor
3	Jazz-Acoustic Factor
4	Rhythm Tendency Factor
5	Combination Factor of Electric Instruments and Rhythm Tendency

Finally, each unit was named by a music expert. The summarized result is shown in Table 2.

5 Experiment by Subject

To investigate at how much rate can the subjects, twenty-five female university students were asked to listen to eight music titles of 4 genres of SMF with MIDI sound randomly, and to judge the genre and the factor for each music.The judgment rate of all the subjects was 66.5%.

To compare the judgment of subjects with this system, Neural Network was trained with 119 titles, and was made to estimate the genre of subtracted one as unknown music.

As a result, both Neural Network and have a judgment rate of 100% for eight unknown music titles. From this, the judgment of this system is higher than that of subjects with general experience of popular music.

6 Summary of Results

In this research, development and evaluation of genre estimation system ware performed aiming for the development of learning support system of music genre. The results are summarized as follows:

(1) The preliminary experiment for experts with an experienced popular music was performed, and a result that says that the factor to estimate the genre tends to be local & partial information was obtained.

(2) From this finding, genre estimation system using Neural Network was developed.

(3) 120 music titles have been identified into 4 genres, Japanese Popular Ballad, Jazz, Hard Rock and Heavy Metal at the rate of 100% by training the Neural Network to identify these 4 genres.

(4) The judgment rate was 66.5% as the result of the estimation experiment for subjects with general experience of popular music.

(5) This system was made to estimate 8 music titles, as an unknown music, out of 120 which were used in the genre estimation experiment by subjects. As a result, the estimation rate of 100% which is higher than that of the subjects (66.5%) was obtained.

(6) Each unit of Hidden Layer in trained Neural Network was enable to be named, and the factors of each unit were able to be extracted by the expert of popular music.

From this finding of 6, providing feedback on the features of the music from Hidden Layer becomes possible by the way of observing the result of meaning explanation of Hidden Layer in which the Neural Network has the feature of the music as a genre, observing the state of fire, and observing the input units which have tendency to make active to the fired units in the Hidden Layer.

From the result described above, the possibility of the development of a learning support system using this system for music genre is shown. And, it was thought that the trained Neural Network of this system has the application possibility not only to the learning support system but also to the supporting composition and adaptation.

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The Rhetoric of the web—A semiotic approach to the design and analysis of web-documents

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This paper seeks to discuss possible approaches through which semiotics and rhetoric can be applied to the World Wide Web seen as a multimedia; or, in other words, possible approaches through which Web-sites and Web-pages can be studied and designed from a semiotic point of view. The aim of the paper is thus to outline a coherent theoretical, methodological and analytical framework for the study and design of Web-documents based on semiotics and rhetoric. This paper has analytical, theoretical, methodological, as well as practical implications. It is of interest in relation to the analytical and theoretical understanding of the new and rapidly growing web medium, and in relation to methods of examining this phenomenon. The study shows the concepts and categories from the field of semiotics and rhetoric are highly relevant to the area of the web and it indicates that the concepts presented here can form the building blocks for a more general 'Semiotics of Cyberspace'. The observations from this study may also have an effect on conventional theory formation and understanding within semiotics, rhetoric, and communication research and media studies. However, it also has implications for the construction and design aspects since the design of Web-documents and Web-sites must be based on actual knowledge of the conditions and possibilities for communication and the construction of signs, codes and meaning in the new medium.

*The paper was not available by the date of printing.

Visual Presentation Format and Knowledge Discrepancy in Scientific Learning

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The effect of presentation formats and the students' prior knowledge on learning a computer-based physics lesson was investigated. Three hundred and fifty seven eighth-grade (novice learners) and ninth-grade (experienced learners) were randomly assigned to different treatments on a class basis. Having worked through the computer lesson, they were given a post-test to assess overall learning performance. A 2 (novice/experienced) X 3 (animation/still graphics/text) ANCOVA (controlling by covariants, physics and mathematics scores) was used to determine the effect of these two variables. It was found that in descriptive learning, the effect of knowledge discrepancy was significant ($p<0.000$); the effect of presentation format was insignificant ($p>0.05$); and the interaction between presentation format and knowledge discrepancy was significant ($p<0.05$). In procedural learning, the effect of knowledge discrepancy was significant ($p<0.000$); the effect of presentation format is significant ($p<0.05$); and the interaction between presentation format and knowledge discrepancy was also significant ($p<0.005$).

Keywords: **Computer Graphics, Animation, Prior Knowledge, Scientific Learning**

1 Introduction

The computer-based technology for implementing an interactive multimedia-learning environment currently exists. However, in spite of these advances in educational technology, the field of educational application still requires the development of a corresponding research-based theory for the design of computer-based instruction using words and graphical materials [1]. Along with recent innovations in computer graphics and animation, the use of various visual strategies has drawn significant attention. There has been research on the effects of different modes of presentation for conveying visual information [2] [3]. However, there is limited evidence of research that directly links instructional strategies to individual differences in preferred learning mode [1]. In evaluating the effects of visual presentation, several issues have been considered. It was assumed that not all people learn in a similar way, and in fact, the effect of the presentation formats (still graphics or animation) in facilitating learning might only apply for certain individuals. The present paper considers learning from different presentation formats within the context of different prior knowledge level of individuals. The design of computer graphics or the use of animation should take into consideration the knowledge discrepancy among learners as they process visual information.

1.1 Graphics and Animation

The use of computer graphics is relatively new in education. However, there has been much research evidence supporting the contention that student learning is affected positively by presenting text with graphics [4] [5]. Furthermore, computer animation offers potential power for presenting visual information to enhance learning [1] [6] [7] [8]. Although there has been widespread belief that animation is superior to

still graphics, in fact, studies reveal inconsistent findings. In various experimental studies that investigated animation in the context of computer-based instruction, some showed significant effects for the animation [9] [10]; whereas some showed no significant difference [11] [12].

Animation provides viewers with two different visual attributes: images and motion [8]. For scientific learning, images and motion are both essential elements for understanding and memorization. Mayer and Sims differentiate the functions of animation in describing textual materials and in helping students construct problem-solving procedures [5]. The motion provided by animation serves several different instructional purposes. In learning descriptive scientific concepts, animation can be used as mnemonic devices to facilitate memorization of principles and rules. However, in learning scientific procedural concepts, the spatial and procedural elements in animation play an important role in deciphering information [13].

In their study of the effects of animation used with different instructional texts, Large, Beheshti, Breuleux, and Renaud found that animation enhanced procedural texts but had no significant effect on descriptive texts [14]. ChanLin observed that instruction with animation was not equally effective for learning descriptive and procedural information [15]. Thus, to design animation effectively, it is important to consider the instructional attributes of the learning materials.

1.2 Prior Knowledge

One important characteristic of learners is their prior knowledge as related to the specific domain of the lesson. Constructivist learning occurs when the learner engages in each of these cognitive processes – selecting relevant images and verbal information, organizing them into respective visual and verbal mental models, and integrating them with each other and with existing knowledge [16]. The difference in cognitive processing depends on the amount of domain-specific knowledge students possess. Discrepancy in prior knowledge might influence the way given visual information is processed, and the degree to which related concepts and information are triggered and connected [5].

The use of animation in computer-assisted learning materials might have greater impact on students with specific prior knowledge than it has on those with higher or lower knowledge levels. Some researchers have identified knowledge discrepancy among learners as influencing effectiveness of visual presentation, although inconsistent findings exist among various studies. Mayer & Anderson found that inexperienced students were better able to transfer what they had learned from a procedural text about a scientific system when visual and verbal explanations were presented simultaneously [3]. Blissett & Atkin reported that individuals with less prior knowledge or lower-ability learners tended to find the learning demands confusing when animation was used [17]. Reid & Beridge found that the use of graphic information caused reading difficulties for less able students [18]. In these studies, the lower-ability students spent more time deciphering the pictorial and textual information. Students with less prior knowledge might devote a large amount of cognitive effort to building a visual representation of given concepts, whereas for high ability students building a visual representation that is based on the animation might be relatively easy [5]. Further study is required before any firm conclusion can be drawn.

1.3 Research Purpose

The purpose of this study was to investigate the effect of presentation formats in facilitating student achievement of different educational objectives. Specifically, the study attempted to determine:

(a) the effect of presentation formats (animation, still graphics, text) and students' prior knowledge (novice, experienced) on learning descriptive and procedural concepts,
(b) whether a specific presentation format (animation or graphics) would be effective for learners with different prior knowledge levels (novice, experienced), and
(c) whether the use of different visual presentation strategies would promote learning of different contents (descriptive, procedural knowledge)

2 Method

2.1 Subjects and Materials

The study consisted of nine classes from eighth-grade and ninth-grade students. A total of three hundred and

fifty seven students participated in this study. The ninth-grade students had more learning experience in mathematics and physics than the eighth-grade students because related geometrical concepts had already been provided in the ninth-grade curriculum. Therefore, the ninth-grade and eighth-grade students were classified as experienced and novice learners, respectively, due to the discrepancy in related prior knowledge and experiences used for application in the problem-solving activities.

During the learning time, students were assigned to treatments on a class basis, and learning their own instructional material independently. The material used for teaching physics was a computer-based learning program, covering lever problems, direction of force, resultant force, composition of forces, component forces, and equilibrium of force. Students learned the instructional materials individually. With an emphasis on using meaningful representations to encourage thinking, the lesson was designed with various scenarios for interaction. Several physics problems were embedded in the scenarios, with adventures for students actively involved in finding the solutions.

Basically, two major knowledge areas were covered: descriptive (knowing what) (Figure 1) and procedural knowledge (knowing how)(Figure2). Descriptive knowledge was referred to a recital of facts or the description of objects or events. In learning and application of the scientific concept, it was essential to provide the basic to-be-remembered information. For example, memorizing the definition of "Resultant" and "Force Vector" provided in the lesson was considered as a descriptive task. In order to enhance memorization of rules and facts, graphics and animation were used in treatment groups to provide memory cues to facilitate semantic connections in learning the scientific concepts (Figure 1). Different from descriptive knowledge, the procedural knowledge was referred to learning and construction of the problem solving steps or procedures involved in physics concepts. To perform a procedural task, learners needed to relate the rules and facts to formulate a sequence of problem solving steps. For example, given two force vectors acting on an object at an angle, students needed to formulate problem-solving procedures to determine one unknown force vector obtained from the resultant and a known force vector. To facilitate construction of procedural knowledge, graphics and animation were used in treatment groups to help students construct a conceptual model in solving the problem (Figure 2).

"Force Vector" is referred to the amount of force with a direction. When two forces acting on an object, then a single force vector forms, which is called "Resultant". One resultant can be formed from many different pairs of force vectors. Thus is you make a parallelogram out of it, you could say that the resultant is equivalent to the diagonal and the force vectors become the sides

Figure 1. Examples of use of graphics for descriptive content

When a cart weighing 20 kg is pushed upward along a slanted surface with an angle of 37° from horizontal. How much force (Fw) is needed to move the cart upward? (Suppose the abrasion from the slanted surface is 0)

Rule 1: When the neighbor sides of a parallelogram are perpendicular to each other, the parallelogram is a rectangular

Rule 2: When the angles of a triangle are 37°, 53°, 90°, then, the sides against those angles will be 3:4:5

Solution:

Step 1: The resultant F (20kg) can be formed by the following force vectors:
Fa is paralleled downward to the slant surface
Fb is perpendicular to the slant surface.

Step 2: F is 20kg, and the angle formed by
Fa and the resultant F is 53° (90° - 37°)
(According to Rule 1 and Step 1)

Step 3: Apply the Rule 2 to get Fa
Fa : Fb: F=3:4:5,
Fa = 3/5F=3/5 * 20=12 Kg

Step 4: If Fw is more than 12 kg, then you will be able to pull the cart upward

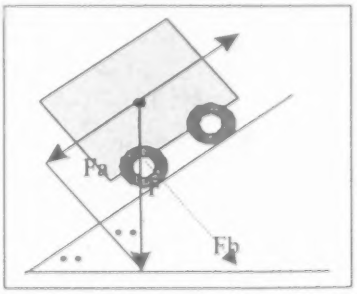


Figure 2. Example of using graphics for procedural content

2.2 Treatments

The lesson was designed in the following three versions:

(1) Treatment 1, Text (non-graphics group): In this version, only textual information was presented to explain scientific concepts. Students receiving this mode of instruction could interact only with the textual content. In a problem scenario, the verbal description was used to provide hints and the solution. Students needed to use their own abilities and related knowledge experiences to visualize the concepts in their mind according to the verbal description.

(2) Treatment 2, Still Graphics: In this version, static graphics with textual information was presented to explain scientific concepts. Students receiving this mode of instruction could interact with the textual content and the still graphics provided. Students could use the external graphic representation to help them visualize the concepts and construct the meaning for the textual materials.

(3) Treatment 3, Animation: In this version, the instructional materials contained textual instructions and animated graphics. Students receiving this mode of instruction could interact with the textual content and the animated graphics. Animation allowed students to comprehend the information through the graphic objects and motions provided by the visual stimuli.

2.3 Criterion Reference Test

After the computer-based learning, a criterion reference test was conducted to assess students' learning performance. The criterion reference test was created based on the content provided. It contained 25 testing items. Twelve of them were to assess students' learning of descriptive knowledge, for example, "What are the factors that might influence the direction of a force?" The other thirteen test items were to assess students' learning of procedural knowledge, for example, "If a bucket weighing 30 kg was pulled by two force vectors, one of which was 18kg, how much force is needed for the other force if the angle formed by these two force vector is 90^{o} ". The Kuder-Richardson Reliability (KR21) for the criterion test items used in this study was 0.76.

3 Results

Three hundred and fifty seven students participated in the study. Among the subjects, 183 were eighth-grade student (novice learners), and 174 were ninth-grade students (experienced learners). To determine the effect of presentation format and students' prior knowledge in descriptive and procedural learning, a 3 (Text/Graphics/Animation) X 2 (Novice/Experienced) ANCOVA was employed. Separate ANCOVAs were also used to test the effect of presentation formats on different knowledge level groups. Since in the Pearson correlation analysis, students' average physics, and mathematics scores were significantly correlated with post-test scores for both descriptive and procedural knowledge ($p<0.05$), these factors were used as covariates for controlling the initial differences among groups.

3.1 Descriptive Learning

For descriptive learning, the 2 X 3 ANCOVA indicated that the main effects were significant for prior knowledge level [$F(1,349) = 20.332$, $p = 0.000$], but insignificant for presentation format [$F(2, 349) = 2.034$, $p = 0.132$] ($\alpha = 0.05$ level). The interaction between the two variables was found significant [$F(2, 349) = 4.451$, $p = 0.012$] (Table 1).

Table 1 Effects of prior knowledge and presentation format (2 X 3 ANCOVA) for descriptive learning

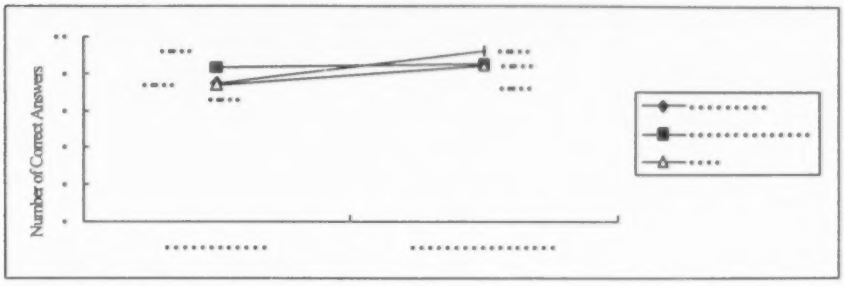
Descriptive Learning	
Effect of prior knowledge: F(1,349)=20.332* p=0.000*** Comparison of means: Experience (8.73); Novice (7.76) Experience > Novice, p=0.000***	Effect of presentation format: F(2,349) =2.034, p = 0.132 Comparison of means: Still Graphics (8.44); Animation (8.37); Text (7.93) Still Graphics > Animation: p>0.05 Still Graphics > Text: p>0.05 Animation > Text: p>0.05
Interaction: F(2,349)=4.451, p=0.012*	

*Significant level: 0.05; **Significant level: 0.01; *** Significant level: 0.001

Covariants: physics and mathematics scores

To test the treatment effect within different prior knowledge groups, separate analyses were conducted. An ANCOVA conducted for eighth grade students, who were novices in the content area, revealed a significant difference [F(2,178) = 3.915, p = 0.022] (• •= 0.05 level). Comparisons of adjusted means using LSD Test indicated that the still graphics group (n=44, M=8.364) performed better than either animation (n=48, M=7.502) or text group (n=91, M=7.412) (p<0.05). Another ANCOVA conducted for ninth grade students, who were experienced in the content area, revealed a marginal but not significant difference [F(2,169) =2.786, p = 0.065]. Comparisons of adjusted means using LSD Test showed that students learning with animation (n=72, M=9.237) performed significantly better than the text group (n=32, M=8.448) (p<0.05), but did not differ from the still graphics group (n=70, M=8.514) (p>0.05). The difference between animation and still graphics was also insignificant (p>0.05) (Figure 3).

Figure 3. Interaction between treatment effect and knowledge discrepancy for descriptive learning



Comparison of adjusted means among different groups

3.2 Procedural Learning

For procedural learning, the 2 X 3 ANCOVA indicated that the main effects were significant for prior knowledge level [F(1,349) = 13.381, p = 0.000], and significant for presentation format [F(2, 349) =4.536, p = 0.011] (• •= 0.05 level). The interaction between the two variables was also found significant [F(2, 349) = 6.296, p = 0.002] (Table 2).

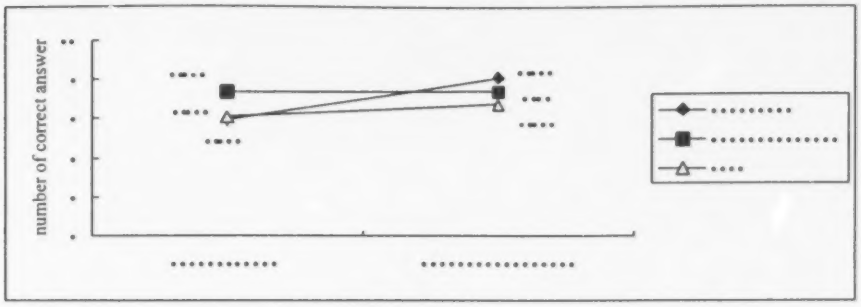
Table 2 Effects of prior knowledge and presentation format (2 X 3 ANCOVA) for procedural learning

Procedural Learning	
Effect of prior knowledge: F(1,349)=13.381• p=0.000*** Comparison of means: Experience (7.44); Novice (6.49) Experience > Novice, p=0.000***	Effect of presentation format: F(2,349) =4.536, p = 0.011* Comparison of means: Still Graphics (7.40); Animation (7.06); Text (6.44) Still Graphics > Animation: p>0.05 Still Graphics > Text: p<0.05* Animation > Text: p>0.05
Interaction: F(2,349)=6.296, p=0.002**	

*Significant level: 0.05; **Significant level: 0.01; *** Significant level: 0.001
Covariants: physics and mathematics scores

Among novice learners, the ANCOVA revealed a significant treatment effect [F(2,178) = 4.462, p = 0.013] (• •= 0.05 level) on procedural learning. Comparisons of adjusted means using LSD Test indicated that students in still graphics group (n=44, M=7.391) performed better than either the animation (n=48, M=5.977) or the text groups (n=91, M=6.105) (p<0.05). Among experienced learners, the ANCOVA revealed an insignificant difference [F(2,169) = 1.980, p = 0.141] (• •= 0.05 level). Comparisons of adjusted means using LSD Test showed that the animation group (n=72, M=8.146) was not significantly better when compared with either the still graphics (n=70, M=7.41) or text groups (n=32, M=6.766) (p>0.05). The difference between still graphics and text groups was also insignificant (p>0.05) (Figure 2).

Figure 2. Interaction between treatment effect and knowledge discrepancy for procedural learning



Comparison of adjusted mean among different groups

4 Discussion

In studying the effect of differing knowledge level and presentation format in learning computer-based materials, the following findings were obtained. The main effect of knowledge discrepancy was significant for both descriptive and procedural learning ($p<0.05$), indicating that the difference in knowledge levels influenced the performance of learning tasks. The main effect of presentation format was significant for procedural learning, but not for descriptive learning, indicating that presentation format (the use of animation, still graphic, and text) might influence different learning to different degree. Apparently, the use of presentation format can influence construction of procedural links, and thus has significant impact on solving procedural problems. In contrast to constructing problem-solving procedural learning, the effect of presentation format in descriptive learning for enhancing memorization of basic to-be-remembered information was not significant.

From the study, the significant interactions between presentation format and prior knowledge level in both descriptive and procedural learning revealed that the need of visual format differed when there was knowledge discrepancy among learners. The effect of treatment was significant ($p<0.05$) among novice learners in both descriptive and procedural learning implying that careful consideration in the use of presentation formats is more essential among novice students than experienced students. Novice learners possessing limited prior knowledge required the use of presentation strategies in assisting learning. With limited learning experiences, they performed better with still graphics in learning both descriptive and procedural content (compared with control group).

The follow-up comparisons among different presentation formats within each prior knowledge group revealed that animation was only better for experienced students in learning descriptive knowledge (compared with control group). Since experienced students had more learning experience in mathematics and physics than the novice students, they could relate geometrical concepts more automatically for performing the instructional tasks. The insignificant treatment effect might be explained by considering that domain-specific knowledge compensating for various presentation formats.

Similar to Blissett & Atkin's observation (1993), those with less prior knowledge or lower-ability learners tended to find the learning demands confusing when animation was used. It is postulated that novice learners might not be able to referentially process animated graphics and textual information for constructing semantic structure and problem-solving procedures simultaneously. Due to the limitations of their prior knowledge, they spent effort in deciphering visual information and adapting the presentation format. The element of motion in animation might require more extensive effort in constructing the connections between textual and graphical information in integrating knowledge. In this case, motion might not be suitable for students when the conceptual links among rules and concepts can be presented with sufficient clarity in a still-graphic form. In addition, the limited capacity of working memory in processing animation among novices might be worth noting.

5 Conclusions

In summary, this research points to the theoretical and practical benefits of the correct choice presentation format. The results of the study imply the need for considering the cognitive processes when using presentation formats. On the theoretical level, this study concludes that the use of presentation formats influences assimilation of scientific knowledge. On a practical level, this study raises the issue of differing mental processes among different learners. Animation should be used with some caution, and cognitive overload and spatial meta-cognition among novice students when performing the tasks is worth noting.

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Xtrain: A GUI based tool for Multimedia Presentations, Instruction, and Research

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Xtrain is a program for scripting and presenting multimedia displays. This program was developed in the Advanced Learning Technologies Laboratory at the University of Memphis and has been used in variety of psychological experiments. This program can combine such multimedia formats as Microsoft agent, Macromedia flash, director and many others that are available for scripting under a GUI Windows environment. Furthermore, Xtrain offers a variety of options for testing styles.

KEYWORDS: **Conversational agents, multimedia applications, Xtrain, Microsoft Agent**

1 Introduction

The idea of embodied conversational agents has generated considerable interest in the realm of HCI recently. Unfortunately, for the most part this has been metaphorical, because computers could not support the needed software. In order for the computer to fully support embodied conversational agents, they would need software that could produce and control many human-like characteristics, such as conversational behaviors, with the ability to mediate the flow of conversation by the use of such things as facial expressions, hand movements and voice intonations [1].

Microsoft made one such attempt at this with their Microsoft Agent program. Microsoft Agent is an interactive interface with conversational capabilities that are embodied in an animated character agent. One example of this is the helper agent in newer versions of Microsoft products such as Microsoft Word and Microsoft PowerPoint. Microsoft Agent is also an optional program for windows 9x operating systems and is available for free download at the Microsoft site. It is compatible with all MS Windows platforms starting with Windows 95. Thus, this agent is readily available for widespread use [5]. The purpose off this paper is not to review Animated Agents for a review, see Johnson, Rickel, and Lester [4].

Furthermore, recent research has shown that the correct use of multimedia presentations can enhance the learning and memory from presented materials. Multimedia in this case refers to any type of pictorial information presented with textual information. However, this form of learning works best with pictorial information shown as an animation that is then coordinated with a narration of any textual information that would be needed [6]. Under the cognitive theory of Multimedia learning, there are three main rules that should be considered for scripting of a multimedia presentation: Spatial contiguity, Temporal contiguity, and Modality. The spatial contiguity effect states that relevant and related concepts should be presented in the same general area of each other (e.g. labeled words should be closer to the object they label than other objects on the screen). The temporal contiguity effect informs us that the various forms of media used during a presentation should correspond with each other by occurring at the same time. Lastly, the modality effect says that if two types of information are presented in the same type of modes, it will hinder learning. However, this can be overcome by presenting information in two modalities. So, printed text and animation on a computer screen would be a hindrance to learning, but a narration and an animation would not [7; 8].

Since Microsoft launched the first version of Microsoft Agent, users and developers have provided a lot of resources for use with the program (e.g., some information can be obtained

fromhttp://www.msagentring.org/agentringmain.html). There are several innovated approached both in the use and the scripting of Agents. For example, mash.exe (http://www.bellcraft.com/mash/) provide a very useful scripting tool for agent programming. Many of these programs have been examined, including Mash, and while they have the ability to control Microsoft Agent, they are lacking the ability to synchronize the Agent program with other forms of multimedia.

The Advanced Learning Technologies laboratory at the University of Memphis developed Xtrain as a way to incorporate embodied agents (Microsoft Agent) and other forms of multimedia into instruction, research, and presentations. Psychologists have used products such as Mel©and Super lab©to run experiments, but these programs cannot incorporate newer technology. Xtrain provides ways to script many different kinds of presentations, including Microsoft Agent, audio and video clips, HTML, Macromedia flash files, Macromedia Director files, and many graphics file formats [2, 3].

This software program serves a duel purpose. It is both an authoring tool and presentation tool. These work together to form a powerful and versatile tool for the presentation of various multimedia displays as well as data collection.

2 Authoring tool

The authoring side of the program has two levels (a) overall organization of frames and (b) detailed construction of individual frames. The overall methodology is similar to the SuperLab program used in experimental psychology. The Presentation is organized in terms of a tree structure with each node in the tree as a pointer to presentation frames. Each frame consists of the smallest unit of information and the frames are logically contingent upon each other. Such tree structure serves as basic navigation guidelines. However, the navigation path can be quite flexible depending on the needs of the user. The tree structure can be created using a user friendly GUI. Each frame corresponding to the tree nods can be any of several formats such as text art, pictures with hotspots, video/audio clips, agent interactions, and animations.

Xtrain has extensive options for frame editing. The program has been arranged so that the different editing functions displayed as individual property tabs. Each tab corresponds to a specific multimedia format. A description of the property tabs will follow.

Property Tabs

2.1 Frame Property Tab

The Frame property tab allows the basic outline of the frame to be determined. From here frame duration is set, alone with the frame' s properties, and the frame type. The duration can be anywhere from self-paced to any amount of time desired measured in milliseconds. The type of multimedia desired can be selected under a Frame properties drop-down menu. Under the Frame type dropdown menu, the type of frame can be specified: Normal, Title, Review, Test, or Interaction.

2.2 Agent Property Tab

This is the general tab that is used to control the agent. Each frame can have up to three agent actions assigned to it. These actions are denoted as agent1, agent2, and agent3. However, these can be assigned as needed for example one agent can be given as many as three actions or three agents can be given one action each. These are selected from the available agents using the Agent dropdown menu. Just below this dropdown menu is a dropdown menu that specifies when the agent will be used. For example, "Action over frame" can be selected so the agent is active while the rest of the frame is running. Just below this are three additional tabs that specify (a) the agent's position on the screen, (b) what the agent will say in each frame, and (c) balloon formatting, if the agent has this option. These are the Action and Gesture tab, Speak and Play tab, and Balloon Setup tab, respectively.

Of these tabs, the Speak and Play tab is of the most importance. This frame in its most basic form allows for text to be entered into a text box. The agent reads this text using a text to speech engine. However, this text box can also contain simple markup within the text. This markup includes such speech parameters as volume, emphasis, pitch and speed. These markup tags can be inserted into the text by inputting the

desired values into the box beside the parameter name on the right portion of the tab and then double clicking the name. This list of parameters also includes a few special tags that can control the flow of the information delivery. These tags permit the agent to skip to a specific frame in the tree structure (Show Frame), or to go to specific frames in a selected Shockwave Flash movie (Go to Frame in Flash Movie). The remaining tag option is Insert Special action. This set of tags allows the user to start, stop, and restart a flash movie, and provides a tag that terminates the program at the end of a presentation. The Speak and Play tab allows for assignment of actions to the selected agent. These actions vary according to the abilities of the selected agent, and can be assigned either at the beginning or the end of the text the agent speaks.

Similar to other agent scripting tool, such as MASH, this agent property editor uses all available Microsoft agents controls. In addition, Xtrain utilizes the bookmark function of MS Agent to control the overall flow of the presentation. In fact it is the use of these bookmarking functions that make it possible to control Multimedia synchronization, such as with Flash animation, which is lacking in the other agent programs.

2.3 Text Display Tab

The text display tab is used to insert text to be displayed on the screen. Doing this involves clicking on the display area, typing in the text to be displayed, and then clicking update. The text will then appear in the display area in the same way that it will be displayed on the screen during the presentation.

2.4 Multimedia Tab

The Multimedia tab allows you to assign audio files, movie files, and wallpaper to the frame. The program supports wave files (.wav) and Enhanced Linguistic files audio formats. If an Enhanced Linguistic file is used Microsoft Agent can be made to appear to speak the file. The movie files available from this tab are AVI (.avi) and Mpeg (.mpg). A Bitmap (.bmp) image can be set as a background that either covers the whole screen or centered.

2.5 Pictures Tab

Using the picture tab, a picture can be added to the frame and manipulated. Xtrain supports two types of graphic files: Bitmap (.bmp) and GIF (.gif). The picture can be located at any point on the screen, centered, or can move from point to point. A hotspot option can be added to the picture to be used to give commands to the agent or to play audio files. Each hotspot can have information, such as text and tagged markup, to be sent to any selected agent.

2.6 Shockwave Tab

Under this tab, there are two options: Flash Movie and Shock Wave Movie. Flash movies and shockwave animations are among the most frequently used multimedia format. Xtrain uses activeX control from macromedia so both types of movies can be manipulated. By loading flash movie from this tab, detailed frame information can be examined so Agents can navigate through the movie. In addition, Xtrain uses FSCommand of flash movie to control Agent and the tree navigation.

2.7 Frame Summary Tab

The frame summary tab gives summary information both at the scripting phase and at the presentation phase. At the scripting phase, it gives a brief overview of the selections made in the other tabs for that frame. If the frame is a test frame, it also contains the correct answers to the questions given in the test frame. After viewing on the other half of this frame, responses are shown. If it was a test frame, the student's responses are listed along with whether the response was correct.

2.8 HTML Tab

The program allows for the incorporation of html documents into presentations. This allows greater flexibility in terms of specialized displays. The format allows for html documents that are locally saved in the Xtrain directory to be displayed and navigated during presentations.

2.9 Test Tab

One other important feature of Xtrain is the testing option. During the scripting phase, frames can be assigned as testing frames on the frame property tab. These frames can be used to capture information from the user. They allow input in such forms as multiple-choice questions, short answer questions, and even essays. At the end of the presentation phase, input from the participant is automatically saved as an ASCII text file. The agent can also be programmed to give dynamic feedback, when the participant gives wrong answers.

3 Presentation Tool

The presentation of the scripted material is as easy as selecting the run drop-down menu and selecting the run entire session option. Alternatively, the Xtrain presentation file (.xtr) can be ran by double clicking its icon in the strain folder. This action occludes all other objects on the screen: only the scripted presentation and a control bar are visible. This control bar is a flash file that allows for the following actions: go back, continue, help, and progress. The presentation continues forward until it reaches the end of the presentation.

4 Summary

Xtrain is a program that is able to integrate multimedia files into one presentation format. The authoring side of the program takes advantage of many Windows' standards for ease of use. It provides a standard Windows interface window with icon buttons and drop-down menus, such as File, Edit, Window, and Help. These offer such options as open and save in the File menu, as well as, cut, copy, and paste in the Edit menu. Xtrain also offers a special drop down menu labeled Run. This menu offers the options of running the entire session or of previewing a selected frame. See Figure 1 for a view of the program. The frames are structured in a tree format that is located on the left of the screen. This tree is created via buttons labeled Brother, for frames on the same level, and Child, for frames on a branching level. Each frame can be scripted using nine different property tabs: Frame Property, Agent Property, Text Display, Multimedia, Picture, Shockwave, Frame Summary, HTML, and Test. These tabs may be individually associated with each frame. It is from these components that the script is produced to set the required tone for the information to be presented. Microsoft agent can also be used to control the flow between frames, so that if the need arises the agent can direct the presentation to any frame in the tree. Furthermore, if a Shockwave Flash file is used, the agent also has the ability to direct the flash movie to any frame within the movie. These options allow for maximum flexibility for the user when scripting a multimedia presentation. In addition to this freedom in scripting, Xtrain offers an easy presentation method that either selecting run entire session from the run menu or by simply double clicking on the created Xtrain file.

References

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